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1863

REPORT
OF THE
NATIONAL ACADEMY OF SCIENCES.

FOR 1863.

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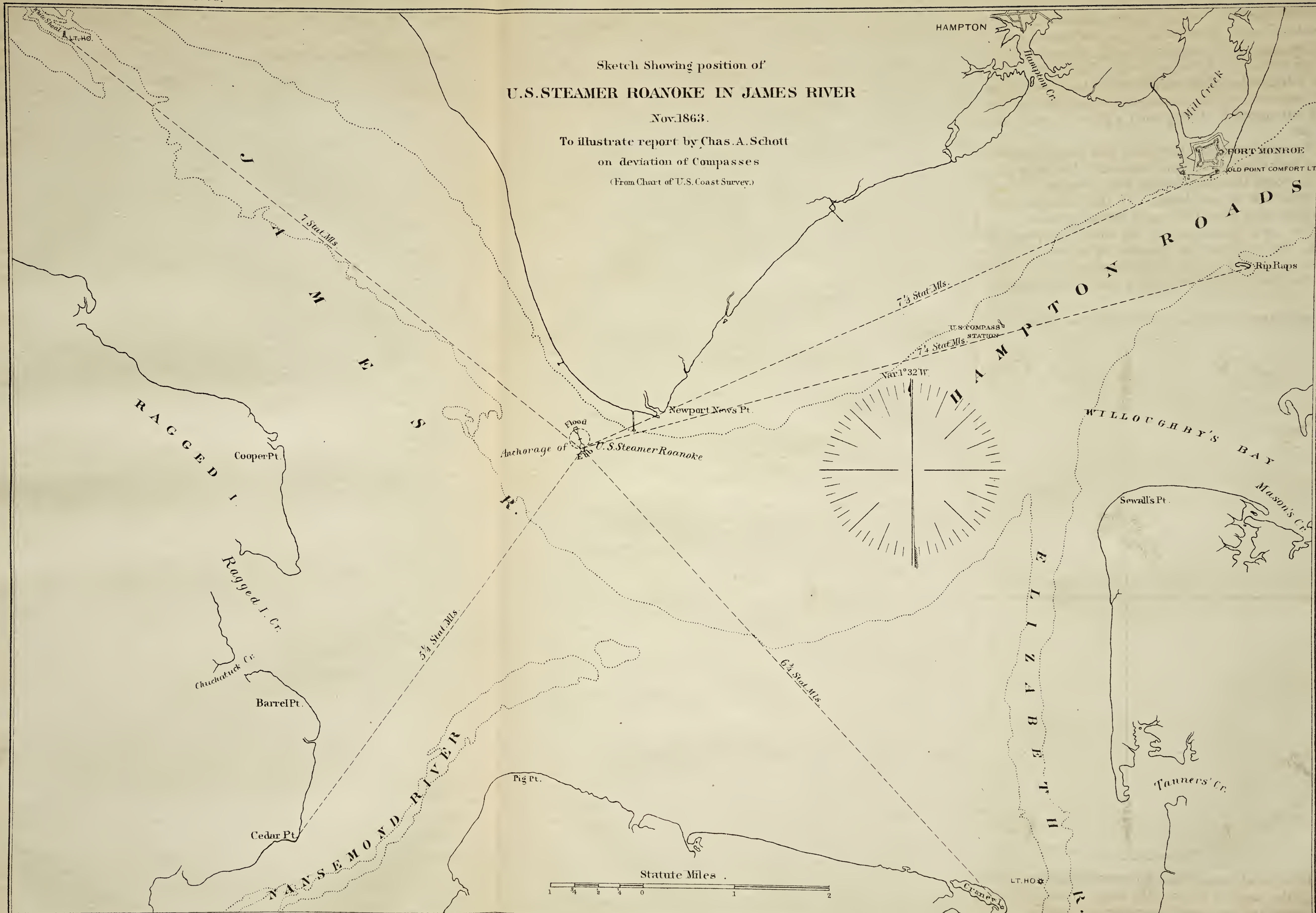

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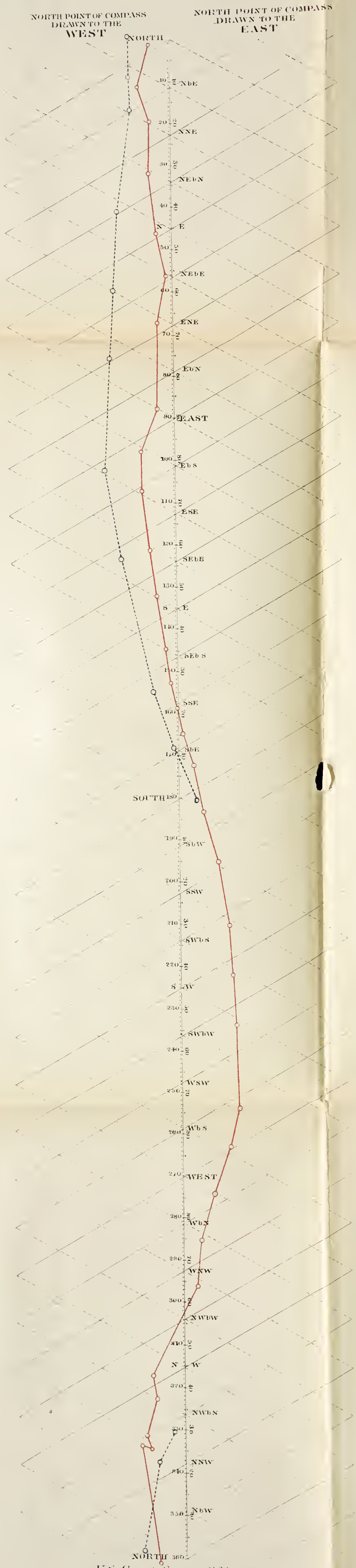
I

DEVIATIONS OF THE

STANDARD AZIMUTH COMPASS, 4FT 10 In. ABOVE DECK.

U.S. Steamer Roanoke, Nov. 18 & 20. — *Hatch down.*

Nov. 19. — *Hatch up.*



U.S. Coast Survey Office 1865.

From British Admiralty Manual.

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II

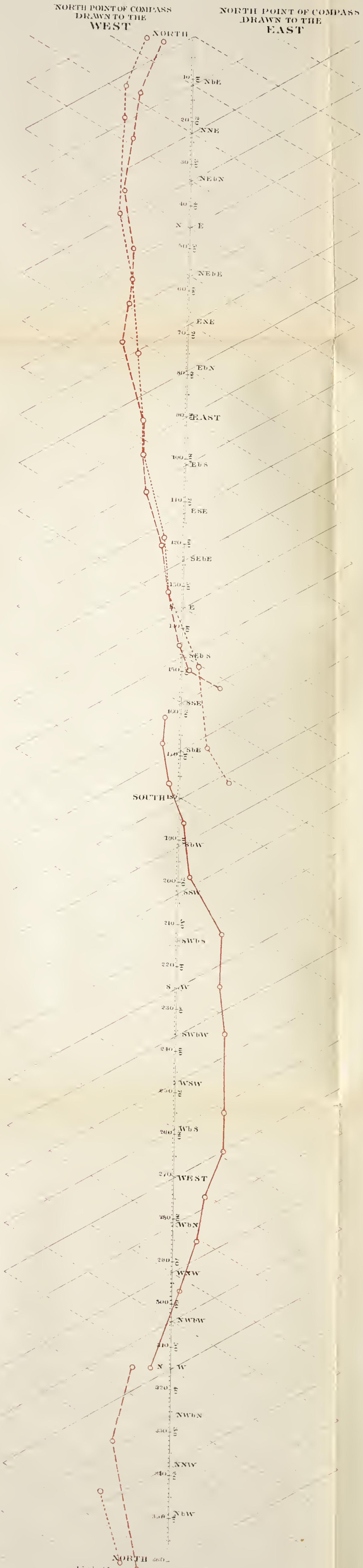
DEVIATIONS OF THE

TELL-TALE COMPASS IN CABIN (ABOUT ONE FOOT BELOW DECK)

——————— *without magnet Nov. 20 (Hatch down)*

– – – – – – *with magnet, hatch down Nov. 18*

.... *with magnet, hatch up Nov. 19*



U. S. Coast Survey Office. 1865.
From British Admiralty Manual.

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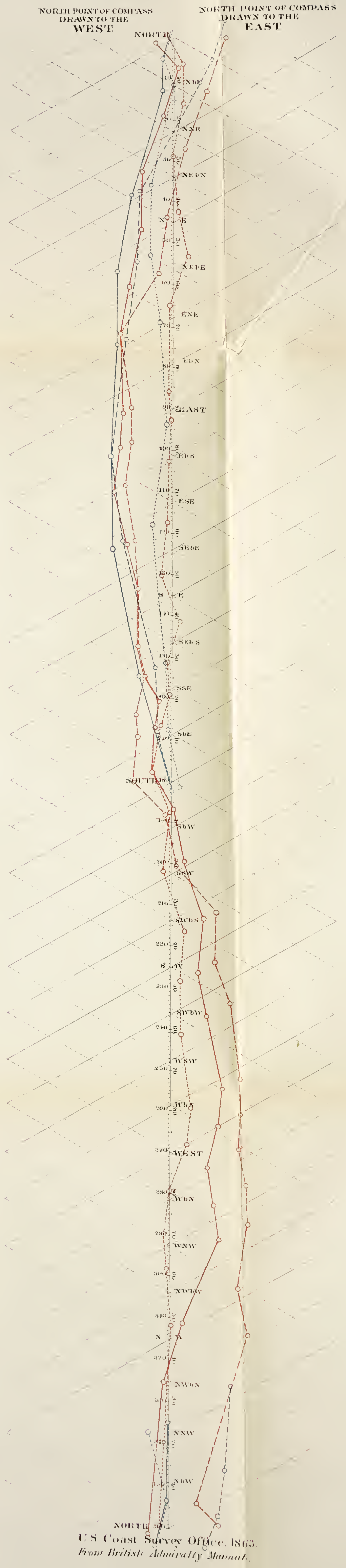
DEVIATIONS OF THE

AFT DECK COMPASS, THE MIDDLE TURRET COMPASS, & FORWARD TURRET COMPASS

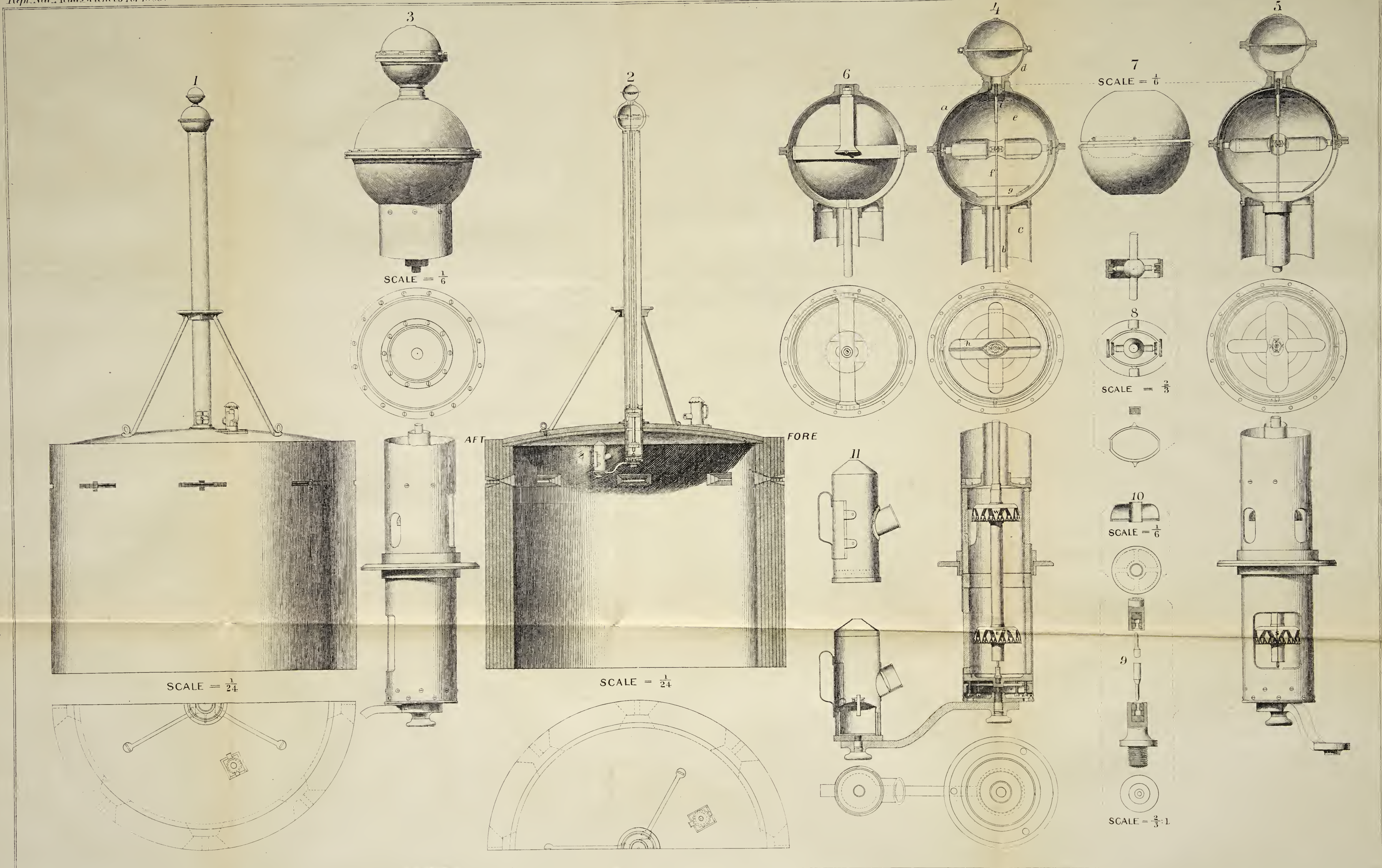
AFT DECK COMPASS	THE MIDDLE TURRET COMPASS	FORWARD TURRET COMPASS
(about 14 ft. above deck)	*(about 21 ft. above deck)*	*(about 20 ft. above deck)*
Nov. 18 & 20. — — — —	*Nov. 18 & 20*	*Nov. 18 & 20* ———
Nov. 19 — — — — — —	*Nov. 19.*	*Nov. 19* ———



U S Coast Survey Office. 1863.

From British Admiralty Manual.

RITCHIE'S LIQUID MONITOR COMPASS.



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REPORT

OF

THE NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1863.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1864.

IN THE HOUSE OF REPRESENTATIVES, *Aprel* 22, 1864.

Resolved, That five hundred copies (extra) of the report of the National Academy of Sciences be printed for the use of the National Academy of Sciences.

Attest:

EWD. McPHERSON, *Clerk*.

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LETTER

FROM

PROFESSOR A. D. BACHE,

TRANSMITTING

A report of the operations of the National Academy of Sciences during the past year.

April 20, 1864.—Referred to the Committee on an Uniform System of Coinage, Weights, and Measures.

WASHINGTON, *April* 20, 1864.

SIR: I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year, in conformity with the requirement of the act of incorporation, approved March 4, 1863.

Very respectfully,

A. D. BACHE,
President National Academy of Sciences.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., March 28, 1864.

SIR: The constitution of the National Academy of Sciences, (section 6, article 5,) incorporated at the third session of the thirty-seventh Congress, requires that "an annual report, to be presented to Congress, shall be prepared by the president, and submitted by him first to the council and afterwards to the academy at its January meeting." In accordance with this provision, I have submitted the following report to the council and to the National Academy at their first stated meeting, and now present it on their behalf to Congress.

The want of an institution by which the scientific strength of the country may be brought, from time to time, to the aid of the government in guiding action by the knowledge of scientific principles and experiments, has long been felt by the patriotic scientific men of the United States. No government of Europe has been willing to dispense with a body, under some name, capable of rendering such aid to the government, and in turn of illustrating the country by scientific discovery and by literary culture.

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It is a remarkable fact in our annals that, just in the midst of difficulties which would have overwhelmed less resolute men, the 37th Congress of the United States, with an elevated policy worthy of the great nation which they represented, took occasion to bring the scientific men around them in council on scientific matters, by creating the National Academy of Sciences. Such has been the way in which the public mind has been stirred before in the annals of other countries, leading to the organization of great systems of education, science, art, and literature, to be encouraged and perfected when more peaceful and prosperous times recurred.

The bill (marked A) to incorporate the National Academy of Sciences was passed in the Senate of the United States in February, in the House of Representatives in March, signed by the President on the 4th of March, and, as if to render it more acceptable to the men of science of the country, without opposition from the time when unanimous consent was asked and obtained by Mr. Wilson, in the Senate, to bring in the bill, to the signature by the President.

In pursuance to the provisions of that act, the members of the National Academy met in New York on the 22d of April, 1863, and completed their organization, renewing by their loyal oath their obligations to serve their country and its constituted authorities, to the best of their abilities and knowledge, on such subjects as were embraced in their charter and upon which they might be consulted, and adopting a constitution and laws which they supposed would enable them to carry on successfully the plans of Congress as sketched in the charter.

Providing for the full and deliberate consideration and arrangement of their laws, by a committee selected for their capability in such a task, the academy adopted the laws presented to their discussion, divided into classes and sections for the consideration of matters of science, elected officers, (see list marked B,) and adjourned to a stated day, the fourth of January, and to Washington, the national capital, with which they were henceforth to be connected in their membership of the National Academy of Sciences.

The first trial of the working of the academy was to be made, and the first effort was to be through the action of a committee on weights and measures, for the appointment of which, to consider the subject of the "uniformity of weights, measures, and coins, considered in relation to domestic and international commerce," the academy had been addressed before its adjournment by the honorable Secretary of the Treasury, S. P. Chase.

It was obvious that the only effective and prompt mode of action by members scattered over the United States, as were the fifty named in the charter, must be through committees. Action must originate with committees and be perfected by discussion in the general meetings of the academy or in the classes or sections—decisions to be finally pronounced by the entire body.

To avoid delay in reports which might be desired by the government to be promptly furnished, the president of the academy was authorized to transmit such reports on their reception. It has not appeared to me, except perhaps in one case, and in that the conclusions of the committee had not reached me, that there was occasion to present the reports until they had been discussed in the academy itself and the views had been adopted, especially as this was, as I have said before, a first trial of the working of our organization. One of the committees thus acting has been able to meet so often, and with so many members at a meeting, as to show that in important cases, where consultation and discussion must be had, there will be little difficulty in effecting meetings, while in most cases correspondence amply suffices for the settlement of the questions involved, and to bring out the results in the form of a report with suggestions.

It will be seen, by the spirit and words of our laws enacted by the authority of the charter, that the members of the National Academy put their time and talents at the disposal of the country in no small or stinted measure, freely,

fully, by the binding authority of an oath, asking no compensation therefor but the consciousness of contributing to judicious action by the government on matters of science. The more the wealth of such men can be drawn out from the treasury of their knowledge the richer the nation will be; and I, for one, do not fear that even the suggestions which may be made to Congress, of subjects in which that knowledge may be most profitably employed for our country and times, will be subject to any supposed taint of self-seeking as to power or influence. Subject to the taint of supposed desire for remuneration it cannot be, as our charter and all our laws look away from such a centre.

Since the organization of the National Academy of Sciences in April last, six committees have been appointed under the authority of article 2, section 4, two by application from the Treasury Department, one from the office of United States weights and measures of the same department, and three by application from the Navy Department, or, under its authority, by the Bureau of Navigation. These applications, referring to physical, chemical, and mathematical subjects generally, have been committed to members of the physical class of the academy, with a few special exceptions only. These subjects are assuredly of eminent practical value, and if the academy, by the reports of its committees or by their own discussions, shall give the information asked for, or shall point out the best ways of obtaining it, the members will at the outset have returned to the government and country the boon of their organization as a national institution. The importance of a body which can thus put the departments and Congress on a level with the knowledge of science of the day, and by disinterested advice may keep it out of the hands of schemers, and provide the methods, intelligence, and knowledge for experimental inquiries, will thus in the earliest days of the organization be put to a complete test.

The subjects embraced in the references of the departments are as follows:

1st. From the Treasury Department. Weights, measures, and coins, their decimalization, &c.

2d. From the Navy Department. Protection of the bottoms of iron vessels from corrosion by sea water and from fouling.

3d. From the Navy Department. Correction of the compasses of naval vessels, especially of iron vessels and of iron clads.

4th. From the Treasury Department. Saxton's new alcoholometer, intended as a substitute for the hydrometer now in use.

5th. From the Navy Department. Inquiry as to the expediency of continuing in their present form the publication by the Navy Department of the Wind and Current Charts and of the Sailing Directions.

6th. From the Treasury Department. Methods of protecting the national currency from being counterfeited.

The subject of weights and measures and of coins is undoubtedly one of the most important in the uses of common life, and upon a right or wrong determination in regard to the system depends the convenience of the great mass of the people of a country, and upon international determinations the convenience of all engaged directly or indirectly in commerce and kindred pursuits.

In the report of the Secretary of the Treasury (Hon. S. P. Chase) in 1861 occurs the following sentence in regard to weights and measures and coins, page 22: "The Secretary desires to avail himself of this opportunity to invite the attention of Congress to the importance of a uniform system and a uniform nomenclature of weights, measures, and coins to the commerce of the world, in which the United States already so largely shares. The wisest of our statesmen have regarded the attainment of this end so desirable in itself as by no means impossible. The combination of the decimal system with appropriate denominations in a scheme of weights, measures, and coins for the international uses of commerce, leaving, if need be, the separate systems of nations untouched,

is certainly not beyond the reach of the daring genius and patient endeavor which gave the steam-engine and the telegraph to the service of mankind."

This committee, No. 1, was appointed as follows: Prof. Joseph Henry, chairman; Prof. J. H. Alexander, Prof. Fairman Rogers, Dr. Wolcott Gibbs, Prof. A. Guyot, Prof. B. Silliman, jr., Prof. William Chauvenet, Dr. John Torrey, Prof. A. D. Bache, (appointed by resolution of academy,) Commodore John Rodgers, United States navy, and L. M. Rutherfurd, esq.

It is not a little strange in our country, where the decimal system of coinage proved at once acceptable, notwithstanding the capital errors committed in, for a long time, keeping in use foreign coins of no convenient relation to the decimal system, that nothing of the kind was effected for weights and measures, and still more strange that the antiquated and cumbrous variety of tables by which articles of different classes were bought and sold should have been retained, that even in our preparation of a national system intended for practical use neither the decimalization of the weights and measures nor the simplicity of one weight of one name should have been adopted. The influence of great names can alone probably explain this, without justifying it.

The committee laid out an extended scheme of reports by their members on the weights and measures of the principal countries of the world, a part of which have been already received, and are, for the present, retained in the archives of the committee.

The discussions in the body of this committee were very strongly in favor of the adoption of the French metrical system, but more strongly, in fact unanimously, in favor of the effort to arrive at a thorough international system—a universal system of weights, measures, and coins, available for the general acceptance of all nations.

The committee has received, through oral communications from the Hon. S. B. Ruggles, delegate appointed by the government of the United States to the International Statistical Congress at Berlin, authentic information as to the propositions made or adopted in that body in regard to weights, measures, and coins.

A communication, marked "C," was received from the honorable Secretary of State, and the following resolution was adopted by the academy in regard to it:

"*Resolved*, That the letter of the Secretary of State be referred to the committee on weights and measures, with power to take such order as may, in their judgment, be necessary."

This committee had several meetings during the recesses of the academy, and finally, the following report, marked "D," was submitted, and the resolution appended to it adopted by the academy:

"*Resolved*, That the committee on weights and measures ask leave to continue their labors and business now in progress, with the power to take action."

The second committee was appointed at the request of the permanent commission of the Navy Department, through the chief of the Bureau of Navigation, on the highly important practical subject of the protection of the bottoms of iron vessels from corrosion by salt water.

The committee consisted of Professor W. Gibbs, chairman; Professor B. Silliman, jr., Dr. John Torrey, Dr. R. E. Rogers, Professor Benjamin Silliman, and Commodore John Rodgers, United States navy, who, after an examination of the subject, presented to the academy a report which was adopted on the 9th of January. They state that the methods hitherto proposed for such protection depend upon one or other of the following principles:

First. Those which are designed to prevent or arrest, wholly or in part, the *corrosion* of the metal.

Second. Those intended to avoid the accumulation of living plants and animals upon the bottoms of iron ships, known technically as *fouling*.

The remedies for these two very distinct classes of injury to iron vessels naturally fall under the following heads:

a. Those in which a metallic coating or alloy is employed, or those in which paints, with or without metallic oxides, are relied on.

b. The use of some poisonous substance as an ingredient of a paint of varnish, for the specific purpose of destroying the life of those plants and animals, the accumulation of which constitutes fouling.

These are discussed in the report which is hereto appended, marked "E."

The committee points out that no reliable systematic experiments have been made upon the relative power of American irons to resist corrosion by sea water which they consider of cardinal importance. They point out also the importance of experiments on the use of oak timber as a backing to the armor of iron vessels, and are of opinion that no method yet proposed can be considered as sufficiently tested to merit a recommendation to the department; that the question is still an open one, and that the naval and commercial interests of the country would, in all probability, be materially advanced by a careful and thorough experimental investigation of the whole subject.

The secretary of the Smithsonian Institution has offered to place the laboratory under his charge at the disposal of the committee for the purpose of investigation.

The committee is of the opinion that no proper investigation can be made of these important subjects, unless an appropriation to defray the necessary expenses be made by the department, or, if necessary, by Congress.

The conclusions of the committee were adopted by the academy in the following resolution:

"*Resolved*, That the report of the committee on the coating of iron ships be adopted, and that a series of experiments on this subject be undertaken by a committee of the academy, whenever the requisite means are provided therefor."

The subject referred by the chief of the Bureau of Navigation, by instructions from the Navy Department, of investigation of the magnetic deviation in iron ships, and of the correction of the compasses, including the correction of those of naval vessels, was referred to committee No. 3, whose preliminary report is presented herewith, marked "F." This committee consists of Professor A. D. Bache, Professor Joseph Henry, Professor B. Peirce, Professor W. Gibbs, Admiral C. H. Davis, United States navy, and Professor Fairman Rogers, and Professor W. P. Trowbridge, appointed under article 2, section 4, of the constitution of the academy. It was first named by the Navy Department, and the chairman was named by the committee, Admiral Davis having been added when the duty was transferred to the academy.

Two important practical results have already flowed from the operations of this committee: one on the suggestion of the Bureau of Navigation, taking out one of the two binnacles which were generally used in the pilot-house of the naval vessels, interfering each with the other in its use, and the correction between April and December of the compasses of 22 iron or iron-clad vessels, or of wooden vessels in which the local attraction was found to be inconvenient from the presence of engines and boilers, of iron rigging and other iron works.

The inconvenience and even danger resulting from the derangement of the compasses on board of many of our iron vessels have been loudly complained of to the Navy Department. The committee adopted Airy's method for these vessels generally, and appointed Mr. A. D. Frye, of New York, who in former years had corrected successfully the compasses of the iron revenue cutters for the Treasury Department, to make the corrections. The difficulties resulting from the rapid movements to sea and port of these vessels have sometimes rendered the effort at correction somewhat imperfect on the first trial, but a persevering application of the method has in no case failed to effect the purpose desired. The committee has also had under successful trial a compass invented

by Mr. Ritchie, of Boston, under the especial direction of the Navy Department, and a compass by Charles A. Schott, assistant in the Coast Survey. These are referred to in the report, lettered "F," of committee No. 3. This report contains also the results of experiments on iron vessels in the course of construction, and of iron turreted vessels, especially of the three turreted iron-clads the Roanoke, and of the monitor Passaic. The compasses of the Roanoke were compared near Newport News by swinging the vessel and noting the deviation at different points. With this report are presented nine sub-reports, as follows:

No. 1. List of iron-clad vessels, in commission or construction, as also of iron vessels, not armored, either purchased, constructed, or being constructed.
No. 2. Report of Professor F. Rogers on operations on United States steamer Ticonderoga.
No. 3. Report of Mr. A. D. Frye.
No. 4. Report by Chas. A. Schott, ass't U. S. Coast Survey.
No. 5. Report by Chas. A. Schott, ass't U. S. Coast Survey.
No. 6. Report by Chas. A. Schott, ass't U. S. Coast Survey.
No. 7 Report by Chas. A. Schott, ass't U. S. Coast Survey.
Magnetic survey of Roanoke and Passaic.
No. 8. Drawings and specifications of Ritchie's fluid compass.
No. 9. Drawings and specifications of Schott's compass arrangement.

A committee, No. 4, on Mr. Saxton's alcoholometer was appointed as follows: Professor Frazer, chairman; Dr. Barnard, Professor Chauvenet, and General Totten. Professor W. B. Rogers was also appointed, but declined. The report, lettered "G," is herewith presented. It gives a lucid description of the instrument, which was itself presented to the examination of the academy, and concludes, after a candid examination of its advantages and defects, by recommending its use to the government in place of the Tralles hydrometer, which is now employed in the collection of the revenue. It is much more simple, more portable, and less liable to breakage than the Tralles instrument. It was approved by the academy on the discussion of the report, and will therefore be presented to the Treasury Department for adoption. It is so small that the bulb and chain, which form the measuring part of the apparatus, is contained in a box $\frac{3}{4}$ inch diameter and 1 inch high.

The following resolution in regard to Mr. Saxton's hydrometer was adopted by the academy on the 7th of January:

"*Resolved*, That the words following be added to the close of the report, viz: It being understood that Mr. Saxton places this invention at the disposal of the government, without any view to remuneration."

A letter from Mr. Saxton, marked "H," is appended to this report.

The next subject (committee No. 5) was brought before the academy in the following letter of the chief of the Bureau of Navigation of the Navy Department:

BUREAU OF NAVIGATION, NAVY DEPARTMENT,
Washington, May 23, 1863.

SIR: I transmit herewith a copy of a letter addressed by me to the Hon. Secretary of the Navy, on the subject of discontinuing the publication, in the present form, of the "Wind and Current Charts," and "Sailing Directions," accompanying them; and now, with the approval of the department, I have the honor to refer the same subject to the National Academy of Sciences, for investigation and report, requesting that, on account of the expense and the public interest, it may receive early attention.

Very respectfully, your obedient servant,

CHARLES H. DAVIS,
Chief of the Bureau.

Professor A. D. BACHE,
President National Academy of Sciences.

"BUREAU OF NAVIGATION, NAVY DEPARTMENT,
"*Washington, May* 21, 1863.

"SIR: I have the honor to inform the department that the charts and sailing directions published by the late superintendent of the Observatory, at the expense of the government, are regarded by hydrographers and scientific men as being prolix and faulty, both in matter and arrangement, to such an extent as to render the limited amount of original information which they actually contain costly and inaccessible.

"I am prepared to recommend the discontinuance of the publication of these charts and sailing directions. But in order that this question of discontinuance may be decided with deliberation, I have to request permission to refer it to the National Academy of Sciences, for investigation, and report to this department.

"I am, sir, very respectfully, your obedient servant,

"CHARLES H. DAVIS,
"*Chief of the Bureau.*

"Hon. GIDEON WELLES,
"*Secretary of the Navy.*"

The committee appointed on this application consisted of Professor F. A. P. Barnard, chairman; Professor J. H. Alexander, Mr. J. P. Lesley, Professor A. Caswell, Chancellor Chauvenet, Professor J. H. C. Coffin, United States navy, Professor J. F. Frazer, Professor A. Guyot, Mr. J. E. Hilgard, Professor B. Peirce, Professor J. D. Dana, and Professor J. Winlock, United States navy, who came to their conclusions early in October, which were adopted by the academy, after discussion, on the 9th of January, and which are expressed in the following resolutions:

"*Resolved by the National Academy of Sciences,* That, in the opinion of this academy, the volumes entitled 'Sailing Directions,' heretofore issued to navigators from the Naval Observatory, and the 'Wind and Current Charts' which they are designed to illustrate and explain, embrace much which is unsound in philosophy, and little that is practically useful, and that therefore these publications ought no longer to be issued in the present form.

"*Resolved,* That the records of meteorological phenomena and of other important facts connected with terrestrial physics, which, under the direction of the Navy Department, have been accumulated at the Observatory, are capable of being turned to valuable account, and that it is eminently desirable that such information should continue to be collected and subjected to careful discussion.

"*Resolved,* That the president of the academy be authorized and requested to communicate to the Secretary of the Navy a copy of the foregoing resolutions and of the report, as a response to the inquiry addressed to the academy upon this subject by that officer."

The report of this committee, marked "I," is appended to this report.

It was, on motion, resolved that a copy of each report, made on the application of the Navy Department, be forwarded by the president of the academy to the honorable Secretary of the Navy.

The 6th committee, appointed by request of the Treasury Department, was upon the plans presented for preventing the counterfeiting of the national currency, and consisted of Dr. Torrey, Professor Henry, Dr. Barnard, Mr. Saxton, Professor Schaeffer, the last named being appointed by request of the department, and under section 4, article 2, of the constitution of the academy. This committee has labored diligently and successfully in the important matters confided to them. The facts which they have developed will, by direction of the academy, be presented confidentially to the Secretary of the Treasury. The general resolutions adopted by the academy are as follows:

"*Resolved,* That the currency committee be empowered to communicate directly with the Secretary of the Treasury, and to take order in reference to the matters intrusted to them.

"*Resolved,* That the President of the academy communicate the foregoing resolution to the honorable Secretary of the Treasury."

A committee was appointed at the first meeting, on the form of a diploma on a corporate seal, and a stamp for books and property, which reported progress at the January meeting, and was continued.

Another committee was appointed to report a rule prescribing the mode of electing foreign associates, which reported at the January session, and was discharged.

I append to this report the minutes of the meeting of organization of the National Academy of Sciences at New York, marked "J,"* and of the first regular session at Washington, in January, marked "K."*

The draft of the constitution and by-laws of the academy, prepared by the committee appointed in April, 1863, was presented and discussed in committee of the whole, engrossed and finally passed, as marked "L," on the 6th of January, 1864.

The following papers were read at the meetings of the January session:

Professor Agassiz: "On the individuality among animals, with reference to the questions of varieties and species."

Professor B. Peirce: "On the elements of the mathematical theory of quality."

Professor A. D. Bache: "On the discussion of magnetic observations made at Girard College observatory in the years 1840–'45, parts IV, V, and VI, *horizontal force.* Investigation of the eleven-year period of the solar diurnal variation and annual inequality, and of the influence of the moon."

Dr. F. A. P. Barnard: "On the force of fired gunpowder, and the pressure to which heavy guns are actually subjected in firing."

Dr. B. A. Gould: "On the reduction of the observations of fixed stars, made by J. J. Lepaute d' Agelet at Paris during the years 1783–'85, with a catalogue of the corresponding mean places referred to the equinox of 1800."

Professor L. Agassiz: "On the metamorphoses of fishes."

Professor B. Peirce: "On the Saturnian system."

Dr. T. Strong: "Notes on the parallelogram of forces, and on virtual velocities."

Professor L. Agassiz: "On the geographical distribution of fishes, as bearing upon their affinities and systematic classification."

Professor A. D. Bache: "On the discussion of magnetic observations made at Girard College observatory in the years 1840–'45, parts VII, VIII, and IX, *vertical force.* Investigation of the eleven-year period of the solar diurnal variation and annual inequality, and of the influence of the moon."

Dr. F. A. P. Barnard: "Description of an anemograph, designed for the University of Mississippi."

"Professor Joseph Henry: "On materials of combustion for lamps in lighthouses."

Mr. L. M. Rutherfurd: "On photographs of the solar spectrum."

General J. G. Barnard: "On tangencies of circles and spheres."

Professor Stephen Alexander: "On observations of the planet Venus, near the times of her inferior conjunction, September 28, 1863, and subsequently."

Professor Stephen Alexander: "Brief note on the forms of icebergs."

These papers were referred to the committee of publication to take order, and to the council to provide the ways and means for publication.

The formalities of the constitution and by-laws in reference to foreign members having been fulfilled, the following were nominated and elected foreign members of the National Academy of Sciences: Hamilton, Baer, Faraday, Beaumont, Brewster, Plana, Bunsen, Argelander, Chasles, and Milne Edwards.

The decease of Mr. Hubbard was announced by the president, and Dr. B. A. Gould appointed to prepare a biographical notice for the next session of the academy.

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* Omitted.

The decease of the following scientific men, not members of the academy, was announced: Doctor Darlington, Mr. Fitz, and Major E. B. Hunt. The following members were appointed to prepare notices of their career: Mr. Torrey, Mr. Rutherfurd, and Mr. F. A. P. Barnard.

After the reading of Dr. B. A. Gould's paper "On the reduction of the observation of fixed stars, made by J. J. Lepaute d' Agelet, at Paris, during the years 1783–'85, with a catalogue of the corresponding mean places referred to the equinox of 1800," the following resolution was unanimously adopted:

"*Resolved*, That the academy, impressed with the importance of a new reduction of the observations of Piazzi, presented by Mr. Gould, recommend that such reduction be made by government at an early period."

The council for the year was elected as follows: Messrs. Davis, Torrey, Rutherford, and Lesley.

The academy determined to meet in New Haven next August, on the first Wednesday, at 10 a. m., at such place as may be fixed by the committee of arrangement.

The committee was appointed as follows: Messrs. B. A. Gould and Hall, secretaries of the classes of mathematics and physics and of natural history; Messrs. Newton, B. Silliman, jr., and Dana.

A resolution was passed making the president of the academy, *ex officio*, a member of all committees.

On Tuesday evening the academy were presented by invitation to the honorable Secretary of the Treasury, S. P. Chase; on Thursday evening to the honorable Secretary of State, Wm. H. Seward; on Friday morning to the President of the United States; on Friday evening came together at the residence of the president of the academy; on Monday visited some of the works of fortification near Washington with General Barnard, and on Tuesday, at 2½ o'clock, adjourned to the next session.

Respectfully submitted.

A. D. BACHE,
President National Academy of Sciences.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States navy, Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States naval observatory, Connecticut; A. A. Humphreys, United States army, Pennsylvania; J. L. Le Conte, United States army, Pennsylvania; J. Leidy, Penn-

sylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, junior, Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries. Wyman, Massachusetts; J. D. Whitney, California, their associates and successors, duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SEC. 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SEC. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose; but the academy shall receive no compensation whatever for any services to the government of the United States.

Approved.

B.

Officers of the National Academy of Sciences, elected at the meetings of organization in New York, April, 1863: President, Prof. A. D. Bache; vice-president, Prof. J. D. Dana; foreign secretary, Prof. Louis Agassiz; home secretary, Dr. Wolcott Gibbs; treasurer, Prof. Fairman Rogers; council, Admiral Chas. H. Davis, Dr. John Torrey, L. M. Rutherfurd, J. P. Lesley.

CLASS A.—Chairman, Prof. B. Peirce; secretary, Dr. B. A. Gould.

CLASS B.—Chairman, Prof. B. Silliman, sr.; secretary, Dr. J. S. Newberry.

C.

DEPARTMENT OF STATE,
Washington, January 8, 1864.

SIR: I have the honor to acknowledge the receipt of your note of the 7th instant, tendering to this department the aid of the Academy of Sciences in any investigations that it may be thought proper to institute with a view to the great reform of producing an uniformity of weights and measures among commercial nations. Be pleased to express to the academy my sincere thanks for this enlightened and patriotic proceeding, and assure them that, with the authority of the President, I shall be happy to avail myself of the assistance thus tendered to me, and to that end I shall at all times be happy to receive

the suggestions of the academy, or of any committee that may be named by it, in conformity with the spirit of the note you have addressed to me.

I am, sir, your obedient servant,

WILLIAM H. SEWARD.

Professor A. D. Bache,
President of the National Academy of Sciences.

D.

Report of the Committee on Weights, Measures, and Coinage.

The committee to which the subject of coinage, weights, and measures was referred, have given the matter as much attention as the time at their disposal would permit, and now beg leave to present a brief statement of what they have done.

Meetings of different portions of the committee were held at Philadelphia, Washington, and Cambridge, and since the commencement of the session of the National Academy nearly full meetings have been held in this city every morning.

As a preliminary step in the investigation of coinage, weights, and measures, the whole subject was divided into a number of separate parts, and these were assigned for special reports to different members.

From these special reports it was intended that the chairman of the committee should prepare a short report on the more important points, to be submitted to the Secretary of the Treasury, conveying certain recommendations. Of these special reports, several in whole and in part have been received.

Mr. Rutherford was added to the committee. The Hon. Mr. Ruggles, of New York, was invited to attend the meetings of the committee, and from this gentleman was received a very interesting communication relative to the action of the International Statistical Congress at Berlin, last year, which is herewith appended.

In accordance with the information thus received, a sub-committee was appointed to confer with Mr. Seward, Secretary of State. This sub-committee reported the following letter from Mr. Seward:

Department of State,
Washington, January 8, 1864.

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I am, sir, your obedient servant,

WILLIAM H. SEWARD.

Professor A. D. Bache,
President of the National Academy of Sciences.

It was impossible for the chairman of the committee to prepare definitely a report in accordance with the foregoing arrangement until he should have

possession of the several special reports and the final determination of the committee.

He has, however, thrown together a series of thoughts on the subject, which may, perhaps, be adopted, with modifications and corrections, as a basis for a report to the Secretary.

The only recommendations which the committee think advisable at this time are embodied in the following resolutions:

1. *Resolved*, That the letter of Hon. William H. Seward be communicated to the National Academy of Sciences.

2. *Resolved*, That the committee on weights and measures have leave to continue their labors and business now in progress, with the power to take action.

3. *Resolved*, That the letter of the Secretary of State be referred to the committee on weights and measures, with power to take such order as may, in their judgment, be necessary.

JOSEPH HENRY, *Chairman.*

INTERNATIONAL STATISTICAL CONGRESS AT BERLIN.

Report from the United States of America.

Mr. Samuel B. Ruggles, delegate from the United States of America, presented the following report:

Mr. President and Gentlemen of the International Statistical Congress:

The government of Prussia having specially requested, through its minister at Washington, his excellency the Baron Gerolt, that the government of the United States of America should send a representative to the international statistical congress to convene at Berlin on the 6th of September, 1863, the President of the United States, on the 14th of August, appointed the undersigned to that office. The session of the congress being so near at hand, the undersigned was necessarily obliged to embark for Europe without delay, and was thus prevented from collecting, in due season, as large a portion as could have been desired of the numerous documents and publications illustrating the statistics of the United States. Much important information, though often wanting in classification and arrangement, is embraced in various official papers issued under public authority, both national and State, and also by boards of trade and other voluntary societies whose labors are more or less statistical. Attempts have been made to impart to American statistics more of an analytical and scientific character, by means of official bureaus to be specially organized for the purpose. The State of Ohio, some years since, under the administration of Governor Chase, the present Secretary of the Treasury of the United States, established a Bureau of Statistics as one of the organs of the State government, which was committed to the charge of Mr. Mansfield, whose copious and instructive annual reports fully justify the selection; while far away in the remote interior, beyond the great chain of lakes, the infant State of Minnesota, with a single exception the youngest in the American Union, containing, by the census of 1860, but 173,000 inhabitants clustered around the headwaters of the Upper Mississippi, and more than fifteen hundred miles from the Atlantic, established, almost at the moment of its birth, a Bureau of Statistics. Two of the annual reports of its able Commissioner of Statistics, Mr. Wheelock, are now submitted to the inspection of the international statistical congress, as affording reasonable ground of hope that, in due time, America may at least approach in scientific accuracy and philosophical arrangement the more mature and perfect performances of the statisticians of Europe.

The Congress of the United States has not yet established a distinct Bureau of Statistics, although repeatedly recommended and urged to do so; but in taking the census of inhabitants, as required by the national Constitution, at intervals not exceeding ten years, the practice has been gradually introduced of superadding, by special direction of Congress, inquiries more or less extensive in regard to various branches of industry and production, and recently embracing social statistics to a moderate extent; so that the compend of the census of 1860, herewith submitted to the international statistical congress, will be found to contain a considerable mass of statistical information, illustrating the material, and, to some extent, the social and moral condition of the nation. Under the limited powers conferred by Congress, the active and intelligent officers who have successively filled the office of Superintendent, and particularly Mr. Kennedy, who participated in one or more of the previous sessions of the international statistical congress, have earnestly exerted their best efforts to render the inquiries authorized by law useful not only to the country, but to the cause of statistical science. It is confidently believed that the enlightened labors of the present body may do much to induce the legislative authorities of the United States to recognize a competent Bureau of Statistics as a national necessity, and thereby place their country on an equality, in that respect, with the most intelligent nations of the world.

Even then, some time must elapse before it will fully attain that power of acute, comprehensive, and thorough analysis in the various branches of statistical inquiry which has so distinguished the eminent European statisticians in their valuable labors in the international statistical congress during the present and the preceding sessions.

It is a cause for general congratulation that those who conduct the public affairs of nations have become generally convinced that a state cannot be wisely or safely governed without an accurate knowledge of quantities. Abstract theories and historical traditions doubtless have their use and their proper place; but statistics are the very eyes of the statesman, enabling him to survey and scan with clear but comprehensive vision the whole structure and economy of the body politic—to adjust, in the finest harmony, all its varied functions—to regulate and invigorate the healthful circulation of every artery and vein, from the central, vital trunk, to the most remote and delicate articulation.

Not only so. In this modern world, where steam has abolished space, the statesman, to deserve the name, must carefully survey the statistics of all the nations that commerce can approach, so that, with nice and skilful hand, he may adapt the administration of his particular government to the due measure of its comparative capacities and powers.

It is under the conviction that this new-born, modern "solidarity of nations" renders the statistics of each important to all, that the undersigned, in behalf of the United States of America, now ventures briefly to invite the attention of the international statistical congress to some of the most prominent features exhibited by the compend of the census of 1860, now before this body, and especially to the evidence which it furnishes of the rate and extent of material progress of the human race in that portion of the New World committed by Providence to the care of the American Union. The exhibition will certainly furnish, to some extent, the means of statistical comparison with other portions of the world, and thereby enable the international statistical congress in due time to discharge what may become a very important and world-wide duty, in classifying the results from the reports of individual countries, and thus to present in scientific form the prominent and distinctive features of the comparative anatomy of nations.

Nor is it to be feared that such a classification or comparison could ever be deemed useless or invidious. On this point the present body, fortunately, is able to refer to the highest authority. The impressive words in the opening

address of the late Prince Albert, who deemed it no derogation from his eminent rank, as the royal consort of the British sovereign, to preside personally over your deliberations, and whose untimely death is mourned in both hemispheres as a loss to the human race, now come to us with solemn earnestness.

In the noble language of that truly exalted prince, such comparisons will only "prove to us afresh in figures, what we know already from feeling and experience—how dependent the different nations are upon each other for their progress—for their moral and material prosperity—and that the essential condition of their mutual happiness is the maintenance of peace and good will among each other. Let them be rivals, but rivals in the noble race of social improvement, in which, although it may be the lot of one to arrive first at the goal, yet all will equally share the prize—all feeling their own powers and strength increase in the healthy competition."

The compend of the census of 1860, and other official documents now submitted to the international statistical congress, will establish the following cardinal facts in respect to the territory, population, and progress in material wealth of the United States of America:

I. The territorial area of the United States at the peace of 1783, then bounded west by the Mississippi river, was 820,680 square miles, about four times that of France, which is stated to be 207,145, exclusive of Algeria. The purchase from France of Louisiana, in 1804, added to this area 899,680 square miles. Purchases from Spain, and from Mexico, and the Oregon treaty with England, added the further quantity of, 1,215,907 square miles, making the total present territory 2,936,166 square miles, or 1,879,146,240 acres.

Of this immense area, possessing a great variety of climate and culture, so large a portion is fertile that it has been steadily absorbed by the rapidly increased population. In May last there remained undisposed of, and belonging to the government of the United States, 964,901,625 acres.

To prevent any confusion of boundaries, the lands are carefully surveyed and allotted by the government, and are then granted gratuitously to actual settlers, or sold for prices not exceeding a dollar and a quarter per acre to purchasers other than settlers. It appears by the report of the Commissioner of the General Land Office, a copy of which is herewith furnished, that the quantity surveyed and ready for sale in September, 1862, was 135,142,999 acres. The report also states, that the recent discoveries of rich and extensive gold fields in some of the unsurveyed portions are rapidly filling the interior with a population whose necessities require the speedy survey and disposition of large additional tracts. The immediate survey is not, however, of vital importance, as the first occupant practically gains the pre-emptive claim to the land after the survey is completed. The cardinal, the great continental fact, so to speak, is this; that the whole of this vast body of land is freely open to gratuitous occupation, without delay or difficulty of any kind.

II. The population of the United States, as shown by the census of 1860, was 31,445,080; of which number 26,975,575 were white, and 4,441,766 black, of various degrees of color—of the blacks, 3,953,760 being returned as slaves. Whether any or what proportion of the number are hereafter to be statistically considered as "slaves," depends upon contingencies, which it would be premature at the present time to discuss.

The increase of population since the establishment of the government has been as follows:

1790	3, 929, 827,			
1800	5, 305, 937,	increase	35.02	per cent.
1810	7, 239, 814,	"	36.45	"
1820	9, 638, 191,	"	33.13	"
1830	12, 866, 020,	"	33.49	"

1840	17,069,453,	increase	32.67	per cent.
1850	23,191,876,	"	35.87	"
1860	31,445,080,	"	35.59	"

This rate of progress, especially since 1820, is owing in part to immigration from foreign countries.

There arrived in the 10 years—

From 1820 to 1830	244,490
From 1830 to 1840	552,000
From 1840 to 1850	1,558,300
From 1850 to 1860	2,707,624
Total	5,062,414

Being a yearly average of 126,560 for the forty years, and 270,762 for the last ten years.

The disturbances in the United States caused by the existing insurrection, and commencing in April, 1861, have temporarily and partially checked this current of immigration, but during the present year it is again increasing.

The records of the commissioners of emigration of New York show that the arrivals at that port alone have been, for—

	From Ireland.	From Germany.	Total, including all other countries.
1861	27,754	27,159	65,529
1862	32,217	27,740	76,306
1863, up to Aug. 20, $7\frac{2}{3}$ months,	64,465	18,724	about 98,000

The proportions of the whole number of 5,062,414 arriving from foreign countries in the forty years from 1820 to 1860 were as follows :

From Ireland	967,366	
From England	302,665	
From Scotland	47,800	
From Wales	7,935	
From Great Britain and Ireland	1,425,018	
		2,750,784
From Germany	1,546,976	
From Sweden	36,129	
From Denmark and Norway	5,540	
		1,588,145
From France	208,063	
From Italy	11,302	
From Switzerland	37,732	
From Spain	16,245	
From British America	117,142	
From China, (in California almost exclusively)	41,443	
From all other countries, or unknown	291,558	
		723,485
		5,062,414

It is not ascertainable how many have returned to foreign countries, but they probably do not exceed a million.

If the present partial check to immigration should continue, though it is hardly probable, the number of immigrants for the decade ending in 1870 may possibly be reduced from 2,707,624 to 1,500,000.

The ascertained average of increase of the whole population in the seven decades from 1790 to 1860, which is very nearly 33⅓ per cent., or one-third for each decade, would carry the present numbers (31,445,080)

by the year 1870 to	41, 926, 750
From which deduct for the possible diminution of immigrants, as above	1, 207, 624
There would remain	40, 719, 126

Mr. Kennedy, the experienced Superintendent of the Census, in the compend published in 1862, at page 7, estimates the population of 1870 at 42,318,432, and of 1880 at 56,450,241.

The rate of progress of the population of the United States has much exceeded that of any of the European nations. The experienced statisticians in the present congress can readily furnish the figures precisely showing the comparative rate.

The population of France in

1801 was	27, 349, 003
1821 was	30, 461, 875
1831 was	32, 569, 223
1841 was	34, 230, 178
1851 was	35, 283, 170
1861 was	37, 472, 132

Being about 37 per cent. in the sixty years. It does not include Algeria, which has a European population of 192, 746.

The population of Prussia has increased since 1816 as follows:

1816	10, 319, 993
1822	11, 664, 133
1834	13, 038, 970
1840	14, 928, 503
1849	16, 296, 483
1858	17, 672, 609
1861	18, 491, 220

Being at the rate of 79 per cent. in forty-five years.

The population of England and Wales was, in

1801	9, 156, 171
1811	10, 454, 529
1821	12, 172, 664
1831	14, 051, 986
1841	16, 035, 198
1851	18, 054, 170
1861	20, 227, 746

Showing an increase of 121 per cent. in the sixty years, against an increase in the United States in sixty years of 593 per cent.

III. The natural and inevitable result of this great increase of population, enjoying an ample supply of fertile land, is seen in a corresponding advance in

the material wealth of the people of the United States. For the purpose of State taxation, the values of their real and personal property are yearly assessed by officers appointed by the States. The assessment does not include large amounts of property held by religious, educational, charitable, and other associations exempted by law from taxation, nor any public property of any description. In actual practice, the real property is rarely assessed for more than two-thirds of its cash value, while large amounts of personal property, being easily concealed, escape assessment altogether.

The assessed value of that portion of property which is thus actually taxed increased as follows: In 1791 (estimated) $750,000,000; 1816 (estimated) $1,800,000,000; 1850 (official valuation) $7,135,780,228; 1860 (official valuation) $16,159,616,068, showing an increase in the last decade alone of $9,023,835,840.

A question has been raised, in some quarters, as to the correctness of these valuations of 1850 and 1860, in embracing in the valuation of 1850 $961,000,000, and in the valuation of 1860 $1,936,000,000, as the assessed value of slaves, insisting that black men are persons and not property, and should be regarded, like other men, only as producers and consumers. If this view of the subject should be admitted, the valuation of 1850 would be reduced to $6,174,780,000, and that of 1860 to $14,223,618,068, leaving the increase in the decade $8,048,825,840.

The advance, even if reduced to $8,048,825,840, is sufficiently large to require the most attentive examination. It is an increase of property over the valuation of 1850 of 130 per cent., while the increase of population in the same decade was but 35.99 per cent. In seeking for the cause of this discrepancy, we shall reach a fundamental and all-important fact which will furnish the key to the past and to the future progress of the United States. It is the power they possess, by means of canals and railways, to practically abolish the distance between the seaboard and the widespread and fertile regions of the interior, thereby removing the clog on their agricultural industry, and virtually placing them side by side with the communities on the Atlantic. During the decade ending in 1860 the sum of $413,541,510 was expended within the limits of the interior central group, known as the "food-exporting States," in constructing 11,212 miles of railway to connect them with the seaboard. The traffic receipts from those roads were—

In 1860	$31, 335, 031
In 1861	35, 305, 509
In 1862	44, 908, 405

The saving to the communities themselves in the transportation, for which they thus paid $44,908,405, was at least five times that amount, while the increase in the exports from that portion of the Union greatly animated not only the commerce of the Atlantic States, carrying those exports over their railways to the seaboard, but the manufacturing industry of the eastern States that exchange the fabrics of their workshops for the food of the interior.

By carefully analyzing the $8,048,825,840 in question, we find that the six manufacturing States of New England received $735,754,244 of the amount; that the middle, Atlantic, or carrying and commercial States, from New York to Maryland, inclusive, received $1,834,911,579; and that the food-producing interior itself, embracing the eight great States of Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, and Missouri, received $2,810,000,000. This very large accession of wealth to this single group of States is sufficiently important to be stated more in detail. The group, taken as a whole, extends from the western boundaries of New York and Pennsylvania to the Missouri river,

through fourteen degrees of longitude, and from the Ohio river north to the British dominions, through twelve degrees of latitude. It embraces an area of 441,167 square miles, or 282,134,688 acres, nearly all of which is arable and exceedingly fertile, much of it in prairie and ready at once for the plough. There may be a small portion adjacent to Lake Superior unfit for cultivation, but it is abundantly compensated by its rich deposits of copper and of iron of the best quality.

Into this immense natural garden, in a salubrious and desirable portion of the temperate zone, the swelling stream of population, from the older Atlantic States and from Europe, has steadily flowed during the last decade, increasing its previous population from 5,403,595 to 8,957,690, an accession of 3,554,095 inhabitants gained by the peaceful conquest of nature, fully equal to the population of Silesia, which cost Frederick the Great the seven-years war, and exceeding that of Scotland, the subject of struggle for centuries.

The rapid influx of population into this group of States increased the quantity of the "improved" land, thereby meaning farms more or less cultivated, within their limits, from 26,680,361 acres in 1850 to 51,826,395 acres in 1860, but leaving a residue yet to be improved of 230,308,293 acres. The area of 25,146,054 acres thus taken in ten years from the prairie and the forest is equal to seven-eighths of the arable area of England, stated by its political economists to be 28,000,000 of acres

The area embraced in the residue will permit a similar operation to be repeated eight times successively, plainly demonstrating the capacity of this group of States to expand their present population of 8,959,690 to at least thirty, if not forty, millions of inhabitants without inconvenience.

The effects of this influx of population in increasing the pecuniary wealth as well as the agricultural products of the States in question are signally manifest in the census. The assessed value of their real and personal property ascended from $1,116,000,000 in 1850 to $3,926,000,000 in 1860, showing a clear increase of $2,810,000,000. We can best measure this rapid and enormous accession of wealth by comparing it with an object which all nations value, the commercial marine. The commercial tonnage of the United States

In 1840 was	2, 180, 764 tons.
In 1850 was	3, 535, 454 "
In 1860 was	5, 358, 808 "

At $50 per ton, which is a full estimate, the whole pecuniary value of the 5,358,808 tons, embracing all our commercial fleets on the oceans and the lakes and the rivers, and numbering nearly thirty thousand vessels, would be but $267,940,000; whereas the increase in the pecuniary value of the States under consideration, in each year of the last decade, was $281,000,000. Five years' increase would purchase every commercial vessel in the Christian world.

But the census discloses another very important feature, in respect to these interior States, of far higher interest to the statisticians, and especially to the statesmen of Europe, than any which has yet been noticed, in their vast and rapidly increasing capacity to supply food, both vegetable and animal, cheaply and abundantly, to the increasing millions of the Old World. In the last decade their cereal products increased from 309,950,295 bushels to 558,160,323 bushels, considerably exceeding the whole cereal product of England, and nearly if not quite equal to that of France. In the same period the swine, who play a very important part in consuming the large surplus of Indian corn, increased in number from 8,536,182 to 11,039,352 and the cattle from 4,373,712 to 7,204,810. Thanks to steam and the railway, the herds of cattle who feed on the meadows of the Upper Mississippi are now carried in four days, through eighteen degrees of longitude, to the slaughter-houses on the Atlantic.

It is difficult to furnish any visible or adequate measure for a mass of cereals so enormous as 558,000,000 of bushels. About one-fifth of the whole descends the chain of lakes, on which 1,300 vessels are constantly employed in the season of navigation. About one-seventh of the whole finds its way to the ocean through the Erie canal, which has already been once enlarged for the purpose of passing vessels of two hundred tons, and is now under survey by the State of New York, for a second enlargement, to pass vessels of five hundred tons, The vessels called "canal boats," now navigating the canal, exceed five thousand in number, and if placed in a line would be more than eighty miles in length.

The barrels of wheat and flour alone, carried by the canal to the Hudson river, were

In 1842	1, 146, 292
In 1852	3, 937, 366
In 1862	7, 516, 397

A similar enlargement is also proposed for the canal connecting Lake Michigan with the Mississippi river. When both the works are completed, a barrel of flour can be carried from St. Louis to New York, nearly half across the continent, for fifty cents, or a ton from the Iron mountain of Missouri for five dollars. The moderate portion of the cereals that descends the lakes, if placed in barrels of five bushels each, and side by side, would form a line five thousand miles long. The whole crop, if placed in barrels, would encircle the globe. Such is its present magnitude. We leave it to statistical science to discern and truly estimate the future. One result is, at all events, apparent. A general famine is now impossible; for America, if necessary, can feed Europe for centuries to come. Let the statesman and philanthropist ponder well the magnitude of the fact, and all its far-reaching consequences, political, social, and moral, in the increased industry, the increased happiness, and the assured peace of the world.

IV. The great metalliferous region of the American Union is found between the Missouri river and the Pacific ocean. This grand division of the republic embraces a little more than half of its whole continental breadth. Portland, in Maine, is the meridian 70° west from Greenwich; Leavenworth, on the Missouri river, in 95°; and San Francisco, on the Pacific, in 123°. By these continental landmarks the western or metalliferous section is found to embrace 28°, and the eastern division between the Missouri and the Atlantic, at Portland, 25° of our total territorial breadth of 53° of longitude.

It has been the principal work and office of the American people, since the foundation of their government, to carry the machinery of civilization westward from the Atlantic to the Missouri, the great confluent of the Mississippi. So far as the means of rapid intercommunication are concerned, the work may be said to be accomplished, for a locomotive engine can now run without interruption from Portland to the Missouri, striking it at St. Joseph, just below the fortieth parallel of latitude. In the twenty years preceding 1860 a network of railways 31,196 miles in length was constructed, having the terminus of the most western link on the Missouri river. The total cost was $1,151,560,829, of which $850,900,681 was expended in the decade between 1850 and 1860.

The American government and people had become aware of the great pecuniary, commercial, and political results of connecting the ocean with the food-producing interior by adequate steam communications. But the higher and more difficult problem was then presented, of repeating the effort on a scale still more grand and continental; of winning victories still more arduous over nature; of encountering and subduing the massive mountain ranges interposed by the prolongation of the Cordilleras of our sister continent through the centre of North America, rising, even at their lowest points of depression, far above the highest peaks of the Atlantic States.

The government, feeling the vital, national importance of closely connecting the States of the Atlantic and of the Mississippi with the Pacific with all practicable despatch, has vigorously exerted its power. On the 1st of July, 1862, nearly fifteen months after the outbreak of the existing insurrection, and notwithstanding the necessity of calling into the field more than half a million of men to enforce the national authority, Congress passed an act for incorporating "The Union Pacific Railway Company," and appropriated $66,000,000 in the bonds of the United States, with large grants of land, to aid the work, directing it to be commenced at the 100th meridian of longitude, but with four branches extending eastward to the Missouri river. The necessary surveys across the mountain ranges are now in active progress, and the construction of the eastern division leading westward from the mouth of the Kansas river, on the Missouri, has actually commenced. The whole of that division, including that part of the line west of the 100th meridian to the foot of the Rocky mountains, is on a nearly level plain, and is singularly easy of construction. Its western end will strike the most prominent point of the auriferous regions in the Territory of Colorado, where the annual product of gold, as stated in the official message of the territorial governor, is from five to ten millions of dollars. The gold is there extracted by crushing machines from the quartz, in which it is found extensively distributed, needing only the railway from the Missouri to cheaply carry the necessary miners with their machinery and supplies. The distance to that point will be about six hundred and fifty miles, which will be passed in twenty-eight hours. When completed, as it easily may be, within the next three years, it will open the way for such an exodus of miners as the country has not seen since the first discoveries in California, to which the American people rushed with such avidity, many of them circumnavigating Cape Horn to reach the scene of attraction.

Meanwhile, a corresponding movement has commenced on the Pacific, in vigorously prosecuting the construction of the railway eastward from the coast at or near San Francisco, which will cross the Sierra Nevada at an elevation of about 7,000 feet, on the eastern line of California, in the 120th parallel of longitude, and there descend into the Territory of Nevada at the rich silver mines of Washoe.

It is not yet possible to estimate with any accuracy the extent of these deposits of gold and silver, but they are already known to exist at very numerous localities in and between the Rocky mountains and the Sierra Nevada, not to mention the rich quartz mining regions in California itself, which continue to pour out their volumes of gold to affect, whether for good or ill, the financial condition of the civilized world. During the last six months gold has been obtained in such quantities, from the sands of the Snake river and other confluents of the Columbia river, as to attract more than twenty thousand persons to that remote portion of our metalliferous interior. The products of those streams alone for the present year are estimated at twenty millions of dollars.

The Commissioner of the General Land Office, in his official report of the 29th December, 1862, states as follows:

"The great auriferous region of the United States, in the western portion of the continent, stretches from the 49th degree of north latitude and Puget sound to the 30° 30′ parallel, and from the 102d degree of longitude west of Greenwich to the Pacific ocean, embracing portions of Dakota, Nebraska, Colorado, all of New Mexico, with Arizona, Utah, Nevada, California, Oregon and Washington Territories. It may be designated as comprising 17 degrees of latitude, or a breadth of eleven hundred miles from north to south, and of nearly equal longitudinal extension, making an area of more than a million square miles.

"This vast region is traversed from north to south, first, on the Pacific side, by the Sierra Nevada and Cascade mountains, then by the Blue and Humboldt;

on the east, by the double ranges of the Rocky mountains, embracing the Wahsatch and Wind River chain, and the Sierra Madre, stretching longitudinally and in lateral spurs, crossed and linked together by intervening ridges, connecting the whole system by five principal ranges, dividing the country into an equal number of basins, each being nearly surrounded by mountains and watered by mountain streams and snows, thereby interspersing this immense territory with bodies of agricultural lands, equal to the support not only of miners, but of a dense population."

"These mountains," he continues, "are literally stocked with minerals; gold and silver being interspersed in profusion over this immense surface, and daily brought to light by new discoveries." "In addition to the deposits of gold and silver, various sections of the whole region are rich in precious stones, marble, gypsum. salt, tin, quicksilver, asphaltum, coal, iron, copper, lead, mineral and medicinal, thermal, and cold springs and streams."

"The yield of the precious metals alone of this region will not fall below one hundred millions of dollars the present year, and it will augment with the increase of population for centuries to come." "Within ten years the annual product of these mines will reach two hundred millions of dollars in the precious metals, and in coal, iron, tin, lead, quicksilver and copper, half that sum." He proposes to subject these minerals to a government tax of 8 per cent. and counts upon a revenue from this source of 25 millions per annum, almost immediately, and upon a proportionate increase in the future. He adds, that "with an amount of labor relatively equal to that expended in California applied to the gold fields already known to exist outside of that State, the production of this year, including that of California, would exceed four hundred millions." "In a word," says he, "the value of these mines is absolutely incalculable."

From the documents and other evidences now before the international statistical congress, it must be apparent that the metalliferous regions of the United States of America are destined, sooner or later, to add materially to the supply of the precious metals and thereby to affect the currency of the world, especially if taken in connexion with the capacity of the auriferous regions of Russia, Australia, and British America, and the possibility of increased activity in the mines of Mexico.

The undersigned would therefore respectfully beg leave to conclude the present report with the suggestion, that a commission be instituted by the body now assembled, with authority to collect such facts as may be gathered from authentic sources, in respect to the probable future production of gold and silver, and to present them for consideration to the international statistical congress at the next or some future session.

S. B. RUGGLES.

BERLIN, *September* 11, 1863.

E.

Report on the protection of bottoms of iron vessels from corrosion, &c.

SIR: The committee of the National Academy of Sciences appointed by you, at the request of the Navy Department, for the purpose of examining the methods proper to be adopted for the protection of the bottoms of iron vessels from injury by salt water, have the honor to report that the methods hitherto proposed for the protection of the bottoms of iron or iron-clad vessels may be divided into two classes:

1st. Those which are designed to prevent or arrest, wholly or in part, the *corrosion* of the metal.

2d. Those intended to avoid the accumulation of living plants and animals upon the bottoms of iron ships, known technically as *fouling*.

The remedies for these two very distinct classes of injury to iron vessels naturally fall under the following heads:

a. Those in which a metallic coating or alloy is employed, or those in which paints, with or without metallic oxides, are relied on.

b. The use of some poisonous substance, as an ingredient of a paint or varnish, for the specific purpose of destroying the life of those plants and animals, the accumulation of which constitutes fouling.

The metallic coatings employed consist of copper, brass, or zinc. Attempts have been made to apply these directly in the form of sheets, or by separating them from the iron by means of wood. It is easy to see that this process is liable to great objections in practice, since it will be difficult to attach the wood, iron, and brass, copper, or zinc firmly to each other without metallic contact through nails or rivets, and without, therefore, producing galvanic currents destructive to the iron of the vessel.

The plan of John Grantham, of England, lately proposed, for securing an exterior sheathing of wood above the iron, and without metallic contact with the exterior copper sheathing, appears to give promise of good results; but it is too recent to justify any decided opinion on its merits.

It has been frequently proposed to coat the iron plates with copper or brass by electrolysis—that is, by a process of electro-plating conducted upon a large scale, and of a uniform and continuous character. The committee is of opinion that no process of electro-plating now known will give a perfectly firm, uniform, and continuous coating of brass or copper upon iron, such as can be relied upon for more than a very short time. A coating of copper or brass not absolutely perfect would produce more injury to the iron than the entire absence of any protection whatever.

Zinced iron, commonly called galvanized iron, has proved unreliable, the zinc soon wearing off; and the spots of iron rust which accumulate upon the exposed surfaces proving more electro-negative than the metallic iron, corrosion proceeds rapidly in spite of the remaining zinc. This remark is not intended to apply to the case of masses of zinc attached mechanically to iron plates, which experience has shown to act beneficially as a protection against corrosion.

A plan of alloying iron plates and scantling with an amalgam of mercury, zinc, and sodium, proposed in 1843 by Mallett, seemed to promise well, but the committee are uninformed as to the results of experience in the English navy in its use.

The paints which have been suggested as used as preventives against corrosion are red lead, oxide of zinc, oxide of copper or salts of copper, red oxide of iron, franklinite, &c., ground up with linseed oil, or with coal tar, asphaltum, and preparations containing gutta-percha or India-rubber. Each of these preparations has some testimony in its favor, but no one appears to have given entire satisfaction.

Of all metallic oxides hitherto employed as paints the best results have been obtained in the use of white zinc or oxide of zinc as a protection from corrosion, and to a good degree from the growth of encrusting animals and plants. The experiments of James Jarvis in 1853, at Gosport navy yard, recorded in the archives of the Navy Department, show this very satisfactorily, and are equally conclusive against the use of red lead, which is now generally abandoned both in England and the United States by the most intelligent constructors.

As against fouling, the use of paints containing arsenical compounds and salts of copper, variously combined with drying oils, asphaltum, rosin, and soap, have, it is understood, given good results in some cases, and are worthy of further investigation.

While experiment has shown that the various sorts of wrought iron employed in naval construction in England differ in respect to their power of resistance to corrosion in clear sea-water from each other in the ratio of 1.14, (as between the best faggoted scrap iron and common Shropshire bar, or common ship plates, at the other extrtmity of the scale,) no reliable or systematic experiments have as yet been made, so far as your committee are informed, upon the relative power of American irons to resist corrosion. It is plain that a subject of such cardinal importance demands a careful experimental investigation.

Your committee are also of opinion that the use of oak timber as a backing to the armor of iron ships is open to the gravest objections, unless reliable means can be found to cut off the corrosion of the iron skin by the acids of the wood. This subject also demands careful study and investigation.

After a careful examination of the subject the committee are of opinion that to none of the methods hitherto proposed can be considered as sufficiently tested to merit a recommendation to the department; that the question is still an open one, and that the naval and commercial interests of the country would in all probability be materially advanced by a careful and thorough experimental investigation of the whole subject.

The secretary of the Smithsonian Institution has offered to place the laboratory under his charge at the disposal of the committee for the purpose of investigation.

The committee is of the opinion that no proper investigation can be made of these important subjects, unless an appropriation to defray the necessary expenses be made by the department, or, if necessary, by Congress.

Respectfully submitted by

B. SILLIMAN, Jr.
JOHN RODGERS.
JOHN TORREY.
B. SILLIMAN.

Prof. A. D. BACHE,
President of the National Academy of Sciences.

F.

Report of the chairman of the compass committee to the National Academy of Sciences, January, 1864.

Under provision of an act of Congress approved March 3, 1863, a commission was appointed on the 28th of March, by the honorable Secretary of the Navy, "to make experiments for the correction of local attraction in vessels built partly or wholly of iron."

Subsequently the Secretary requested the National Academy of Sciences "to investigate and report upon the subject of magnetic deviations in iron ships;" and, in accordance therewith, the members of the former commission, with the addition of Admiral Davis, chief of the Bureau of Navigation, were appointed a committee by the president of the academy, under date of the 20th of May, to perform the services requested by the Navy Department. The president being named as chairman of the first commission, in the letter of request from the Navy Department, associated with him, as members of the committee of the academy, Professors Joseph Henry, Wolcott Gibbs, and Benjamin Peirce, Admiral Davis, and Professor W. P. Trowbridge. Mr. A. D. Frye, of New York, was assigned to assist the committee by applying Professor Airy's method to the correction of deviation, and by observing peculiarities of construction in the vessels.

Precedent to this action the commission had been formally requested "to act

as a scientific committee to superintend the placing of the standard compass on board the United States steamer Circassian, and to examine the correction and register of its deviations," and for that purpose held its first meeting on the 19th of March, at New York. The compass deviations of the Circassian were examined at the compass buoys near Sandy Hook, and corrected. The observations of the commission at this meeting resulted in dispensing with one of the compasses of the two usually kept in the binnacle, and in the issue of a general order to that effect from the Bureau of Navigation. The second meeting of the commission was held, for conference, at the Brevoort House, on the 21st of April.

Communications received from Commander Wyman, United States navy, in April, and from Lieutenant Commander W. B. Eaton, the commander of the Circassian, in May, after the return of the vessel from the Gulf of Mexico, show that the working of the compasses was improved by the changes made in regard to them at the instance of the commission. Some of the alterations desirable, but deferred by reason of the orders for sailing in March, have since been made.

As president of the National Academy of Sciences and chairman of the commission on the treatment of compasses, I reported in June to the Bureau of Navigation the facts concerning the previous and subsequent working of the compasses of the Circassian.

The compasses of the United States steamer Sunflower were corrected early in May, and reported on. This was a wooden vessel, and the position in which her compasses had been used was only six feet from the boiler. The adjustment was made at the compass buoys.

Near the end of May, on being informed that the compasses of the steam sloop Ticonderoga, then at Philadelphia, needed correction, where no compass station had yet been established, Professor Fairman Rogers was, by request of the Bureau of Navigation, specially assigned to make the requisite investigations, assisted, as the committee had been in the previous cases, by Mr. Frye. The treatment needed for the correction of the compasses was promptly applied, and reported on in detail by Professor Rogers. The peculiarity in this case was that, although the vessel was of wood, the mizzen shrouds being of iron and the binnacle being directly under them, none of the ordinary methods of correction would avail. The difficulty was overcome by substituting hemp for iron in the shrouds.

On the iron clad frigate Roanoke numerous experiments, directed by the committee, had been made by Mr. Frye, in March, April, and May, while the vessel was preparing for sea.

In June the compasses of the iron prize steamer Adela were corrected. Their position had been over the engine and between the smoke stacks.

At the compass station, Mr. Frye adjusted the compasses of the iron steamer Granite City in July, and those of the Gertrude and of the prize steamer Aries in August. The large wooden steamer Quaker City was also adjusted for compass deviation at the buoys in August, and the Fort Jackson early in September.

In addition to these operations, which were made under the immediate direction of the committee, Mr. Frye corrected the compasses of the wooden United States tug-boat Rescue, and re-set those of the prize steamer Duoro. He also examined the compass arrangement of the wooden steamer Iron Age, at Boston, in June, and the turret of the monitor Passaic in the latter part of June, after her return from Charleston bar. Experiments were made, at the instance of the committee, on the iron-clad steamer Onondaga, in the middle of April, when that vessel was under construction at Green Point. The iron material and the tools then in use about the vessel, or scattered along the deck, made it impracticable to draw any conclusion from the experiments.

Mr. Frye visited the screw sloop Shenandoah early in July, at Boston, but changes then being made in her machinery deferred the correction of her compasses until September. The corrections were made at the Philadelphia navy yard, where, also, and at the same time, the compasses of the iron prize steamer Bermuda were adjusted.

The compass on the iron transport Karnak was adjusted by Mr. Frye on September 22, at Jersey City; also that of the wooden gunboat Paul Jones, at Sandy Hook. On the latter vessel the compass had to be put in another position, and was then found to work satisfactorily.

In October Mr. Frye adjusted the compasses of the wooden gunboat Nipsic, and of the wooden side-wheel gunboat Sassacus, and in November that of the iron propeller Emma, and of the iron gunboat Aries. The compasses of the wooden propeller Governor Buckingham were also adjusted.

The chairman of the committee also availed himself of the services of Charles A. Schott, assistant in the United States Coast Survey, for some special examinations of the magnetic condition of the turreted and iron-plated steamer Roanoke, and the Ericsson battery Passaic, and also of the deviations of the compasses on the former vessel. Four reports have been submitted by Mr. Schott, of which the following is a general statement of contents:

In the first report, (on results of observations made in June, 1863,) the local deflections of the needle on board the Roanoke, then at the Brooklyn navy yard, were ascertained at nine stations at equal elevations from the deck, and a curve of no deviation or nodal line was located for that special heading of the vessel (south 28° east.) Experiments were made as to the height above deck and above the turrets, at which the local deviation will disappear. Although an elevation of six feet, if not in the immediate vicinity of elevated masses of iron, will generally eliminate the larger deflections, no practicable height could be detected at which the local deflections would become insensible. At the same nine deck stations, one foot above deck, the horizontal component of the magnetic force was measured and compared with that at a shore station, from which it resulted that the horizontal force was slightly greater on the starboard side, and slightly less on the port side, than on shore. Observations for dip and total force were also made. The dip on the starboard side was found greater, and on the port side smaller; the total intensity was, upon the whole, less than the normal value on shore. The distribution of the magnetic polarity on the outer and inner surfaces of the turrets (gun and steering turrets) was traced out graphically. The position of the curve of no polarity was found to depend upon the dip, and indicated that the turrets were polarized by induction showing south polarity all around the top, (outside,) and north polarity at the bottom, (outside,) excepting a small sector of south polarity turned toward the south meridian; on the northern side the south polarity ascended to within one foot of the top. On the inner side the curve of no polarity (or, as it might be termed, magnetic equator) is more difficult to trace out, on account of the very feeble directive force, which is neutralized by the opposite surfaces. While the plane of the outer neutral curve was nearly at right angles to the direction of the dip, the inner one was level, rising to a few feet from the bottom, with south polarity above and north polarity below it, irrespective of minor fluctuations. The steering turret polarity partakes of the same general character as that noticed for the gun turrets.

In the second report, (upon observations obtained on board the Roanoke in June, 1863,) the compasses were compared for two opposite headings of the vessel; also some additional observations were made as to the extent in altitude of local deflections. Vertically, above or below the neutral line traced out for a particular heading, no deviations were found. A new set of observations for horizontal force, dip, and total force, with the vessel in the opposite direction, were made at the deck stations, and extended to the cabin, the hold, and

the inside of the turrets. Ample directive force was found in the cabin, but only a small amount inside the turrets. Of the total force nearly 88 per cent. was found neutralized. The polarity of the turrets was also re-examined. The heading of the vessel being opposite, it was found changed with respect to the turret; that is, where we had the highest ascent of north polarity the day previous, we now had the lowest; in other words, the turrets seem to be wholly under the inductive power of the earth's magnetism. We may conceive the magnetic fluid to remain unchanged while the turret is turning, either along with the vessel or separately. After an interval of twelve hours the exact position of the curves (of no polarity) were not re-established; thus the south polarity had still to ascend on each turret (outside) two feet to reach its former height; and at the bow turret the north polarity also was still two and a half feet above deck, in the place where we had before the small sector of south polarity. It appears that under the same conditions the change in one turret is slower than in another, depending upon the hardness of the iron, and the amount and force of permanent magnetism. In connexion with the above, it should be stated that the polarity of the vessel also changes as it turns, and thus affects the polarity of the turrets to some extent. The principal change of polarity, upon reversal, is most likely instantaneous; the greater part is accomplished within twelve hours after, but it takes several weeks before a magnetic equilibrium is established. The permanent magnetism of the turrets evidently plays a very subordinate part in the phenomenon. The magnetism of the armor plates was also examined. They showed a very narrow strip of north polarity near the bottom and on one side, each plate the same, if under the same influence of the earth's induction, and above the curve of no polarity which divided the rudder curtain, the lower part of which was found north magnetic, the upper part south magnetic; the ram was south magnetic, as far as it could be examined.

The third report gives the observations and results of a magnetic survey of the monitor Passaic, then at the Brooklyn navy yard, (June, 1863.) It investigates the polarity of the turrets and of the side armor; the horizontal and total force below and above deck and inside the turrets; also the deflections of the compass in various localities, and concludes with some notes on the polarity of plates and shells. The results, in general, present no new features from those developed on the Roanoke. The plating of the Passaic differs from that of the Roanoke. No change of polarity was observed near the seams, as the plates are in close contact; the upper part of each was south magnetic, the bottom part north magnetic. The horizontal force in the cabin and in the vicinity of the deck was smaller than its normal value; inside the turrets two-thirds of it was found neutralized; in the gun turret there remained but 13 per cent. of the total force. It is stated that the measured amount of force in the cabin is unfavorable to the mounting of a compass. The polarity of balls and shells was also examined. The magnetic equator seems to be below the centre, with north polarity at the bottom, and south polarity on the top. With a view of getting at the induction time, shells were rolled in the magnetic meridian, but they could not be moved *fast enough* to bring up the bottom north polarity.

The fourth report, submitted in December, 1863, is of a thoroughly practical nature, and investigates the law of the deviation of the compasses on board the Roanoke, then lying off Newport News, Virginia. The deflections for each point of the horizon, for five compasses, were ascertained and presented in tabular form, graphically on Napier's diagrams, and also analytically. A standard azimuth compass was mounted on deck, and its deflections were determined by means of azimuth observations upon the sun, the time and latitude and magnetic declination being known; also by means of bearings of objects laid down on a Coast Survey chart; and, finally, by means of the magnetic bearings of the referring object, which was about seven miles distant. The correct magnetic bearing of the ship's head for each point of this compass thus

became known; and the simultaneous readings of the other compasses, as the vessel swung round by the reversal of the tidal current, furnished the means of determining the deviations of each of the compasses. On the third day the vessel swung round in the opposite direction. An attempt had previously been made to turn her at slack water, with the aid of three steam-tugs, but failed on account of her great draught. Deviation tables and steering tables are given for the aft deck compass, the tell-tale cabin compass, (two sets,) the standard azimuth deck compass, the middle turret and the forward turret compasses. The general character of the curves of deviation is the same for all, viz: a small deviation when the ship heads north or south, and a large deviation when easting or westing; in the former case the deviation was opposite, or west; in the latter, east; a character different from that generally observed in wooden vessels, and indicative of the vessel being plated while heading to the northward and westward. The greatest deflections observed were about 1½ point, excepting those of the middle turret, which were very small, hardly exceeding ¼ point. This compass and that above the forward turret are mounted nearly 21 feet above deck. For the latter compass a steering diagram was also presented.

In placing compasses, particular attention is to be paid to the sufficiency of directive force; and in correcting them, the magnets used should not be placed too near the compass, as the inductive power of the magnet comes then powerfully into play. The magnets used should also be well seasoned; that is, not less than one year should have elapsed since their magnetization. On this point, Appendix No. 32, of the Coast Survey report for 1857, may be consulted. As a matter of course, all compasses should be placed on the midship fore and aft line, and no iron or other compass be allowed in their immediate vicinity.

With this report are also presented two designs for mounting compasses on board of turreted iron vessels; one by Mr. Ritchie, which has already been practically tested, and a second one by Mr. Schott, a modification of that used on the middle turret of the Roanoke.

Respectfully submitted for the committee by

A. D. BACHE, *Chairman.*

LIST OF APPENDIXES TO THE FOREGOING REPORT.

1. List of iron-clad vessels in commission or construction,
2. Report by Professor F. Rogers on operations on the Ticonderoga.
3. Report by Mr. A. D. Frye.
4. Report by Charles A. Schott, assistant Coast Survey. } Magnetic survey of Roanoke and Passaic.
5. Report by Charles A. Schott, assistant Coast Survey.
6. Report by Charles A. Schott, assistant Coast Survey.
7. Report by Charles A. Schott, assistant Coast Survey.
8. Drawings and specifications of Ritchie's fluid compass.
9. Drawings and specifications of Schott's compass arrangement.

Appendix No. 1.

UNITED STATES NAVY.

List of iron-clad vessels in commission or construction, as also of iron vessels not armored, either purchased, constructed, or being constructed.

Agamenticus, iron-clad, second rate, at Portsmouth.
Benton, iron-clad, third rate, of Mississippi squadron.
Baron de Kalb, iron-clad, third rate, of Mississippi squadron.
Chillicothe, iron-clad, fourth rate, of Mississippi squadron.
Chickasaw, iron-clad, third rate, of Mississippi squadron.
Catskill, iron-clad, third rate, of North Atlantic blockading squadron.
Camanche, iron-clad, third rate, at Jersey City.
Cincinnati, iron-clad, third rate, of Mississippi squadron.
Carondelet, iron-clad, third rate, of Mississippi squadron.
Canonicus, iron-clad, third rate, at Boston.
Catawba, iron-clad, third rate, of Mississippi squadron.
Dictator, iron-clad, first rate, at New York.
Dunderberg, iron-clad, first rate, at New York.
Essex, iron-clad, third rate, of Mississippi squadron.
Eastport, iron-clad, third rate, of Mississippi squadron.
Galena, iron-clad, third rate, of North Atlantic blockading squadron.
* Indianola, iron-clad, fourth rate, of Mississippi squadron.
Kickapoo, iron-clad, third rate, of Mississippi squadron.
* Keokuk, iron-clad, third rate, of South Atlantic blockading squadron.
Louisville, iron-clad, fourth rate, of Mississippi squadron.
Lexington, iron-clad, fourth rate, of Mississippi squadron.
Lehigh, iron-clad, third rate, of North Atlantic blockading squadron.
Mound City, iron-clad, third rate, of Mississippi squadron.
Marietta, iron-clad, fourth rate, of Mississippi squadron.
Milwaukie, iron-clad, third rate, of Mississippi squadron.
Montauk, iron-clad, third rate, of South Atlantic blockading squadron.
Manhattan, iron clad, third rate, at Jersey City.
Mahopac, iron-clad, third rate, at Jersey City.
Manayunk, iron-clad, third rate, at Pittsburg.
Monadnock, iron-clad, second rate, at Boston.
Miantonomah, iron-clad, second rate, at New York.
Nantucket, iron-clad, third rate, of South Atlantic blockading squadron.
Nahant, iron-clad, third rate, of South Atlantic blockading squadron.
Neosho, iron-clad, third rate, at St. Louis.
New Ironsides, iron-clad, first rate, of South Atlantic blockading squadron.
Ozark, iron-clad, first rate, at Mound City.
Osage, iron-clad, first rate, at St. Louis.
Onondaga, iron-clad, second rate, at New York.
Oneoto, iron-clad, third rate, at Cincinnati.
Patapsco, iron-clad, third rate, of North Atlantic blockading squadron.
Passaic, iron-clad, third rate, of North Atlantic blockading squadron.
Pittsburg, iron-clad, third rate.
Puritan, iron-clad, first rate.
Roanoke, iron-clad, first rate.
Sandusky, iron-clad, fourth rate.
Sangamon, iron-clad, third rate, at Chester, Pennsylvania.
Saugus, iron clad, third rate, at Wilmington.
Tuscumbia, iron-clad, third rate, at Cincinnati.
Tippecanoe, iron-clad, third rate, at Cincinnati.

Tonawandah, iron-clad, second rate, at Philadelphia.
Tecumseh, iron-clad, third rate, at Jersey City.
Winnebago, iron clad, third rate, at St. Louis.
Weehawken, iron-clad, third rate, of South Atlantic blockading squadron.

Light-draught single-turreted vessels now in construction.

Waxsaw, iron-clad, at Baltimore.
Napa, iron-clad, at Wilmington.
Tunxis, iron-clad, at Chester.
Yazoo, iron-clad, at Philadelphia.
Umpqua, iron-clad, at Pittsburg.
Klamath, iron-clad, at Cincinnati.
Yuma, iron-clad, at Cincinnati.
Naubuc, iron-clad, at Jersey City.
Cohoes, iron-clad, at New York.
Koka, iron-clad, at Boston.
Suncook, iron-clad, at Boston.
Casco, iron-clad, at Boston.
Chimo, iron-clad, at Boston.
Shawnee, iron-clad, at Boston.
Squando, iron-clad, at Boston.
Modoc, iron-clad, at New York.
Wassuc, iron-clad, at Philadelphia.
Nauset, iron-clad, at Boston.
Etlah, iron-clad, at St. Louis.
Shiloh, iron-clad, at St. Louis.

Iron vessels purchased.

Aries, screw, prize.
Bermuda, screw, prize.
Britannia, side-wheel, prize.
Calypso, screw, prize.
Clyde, side-wheel, prize.
Gertrude, screw, prize.
Niphon, screw, Boston.
Princess Royal, screw, Boston.
Queen, screw, Boston.
Virginia, screw, Boston.
Peterhoff, screw, Boston.
Merrimack, screw, Boston.
Emma, screw, Boston.

Appendix No. 2.

Journal of operations on United States steamer Ticonderoga.—Compass committee National Academy of Sciences.

1863, *Friday, May* 29.—Visited Ticonderoga at navy yard with Mr. A. D. Frye, operator for the committee. Examined her compasses; found two binnacle compasses three feet eight inches apart, and one standard azimuth over stern-post. The officers complained that all the compasses differed widely, and spun with the motion of the propeller.

Examination showed that the centre points of binnacle compasses were higher than suspension of gimbals.—(For details see letter to Professor Bache, of May 29.)

Her compasses read as follows:

	STANDARD.	BINNACLE. Starboard.	BINNACLE. Port.
11*h.* 35*m.*	W. 1° S.	W. 2° N.	W. 5 S.
	W. 2° S.	8	....
11 42	W.	11	W.
43	W.	13	W. 3° N.
44	W. 2° N.	20	13
	4½°	27	23
54	32	46	39
12 45	64	67	82

As we could not swing the ship where she was, I decided to write to Washington for permission to move her either to New York compass station, or to League Island.

(See letter to A. D. B., May 29.)

Saturday, May 30.—The compasses were sent to Riggs by Lieutenant Commanding Jeffers, ordnance officer, but they could not do anything to them to-day.

Monday, June 1.—Met Frye at Riggs's, at 10 a. m., to examine compasses. Found that they were very weak and sluggish; one of the light cards especially seemed to have lost all its charge. They have now all been recharged by Riggs.

The four-needle cards (heavy cards) had all their north poles in one direction. The charge of the needles was tested both by observing their directive force and by hanging small pieces of iron to them.

Orders having come to move the vessel to League Island compass station, we went to the navy yard and found that she would go down at 12 m.

At half past two p. m. we joined her at League island with the compasses, which had had their centre pins cut down and their needles recharged. We removed one binnacle (starboard) and placed the other (port) in the axial line of the ship. Mr. Frye remained on board all night, and spent the next day—

Tuesday, June 2—in examination of the compasses, swinging the ship, and searching for a good place for a standard compass. The latter he found just forward of the wardroom skylight, but in the way of working the large pivot gun, so that a permanent compass cannot be used there. A movable box has been made and the position marked by copper nails.

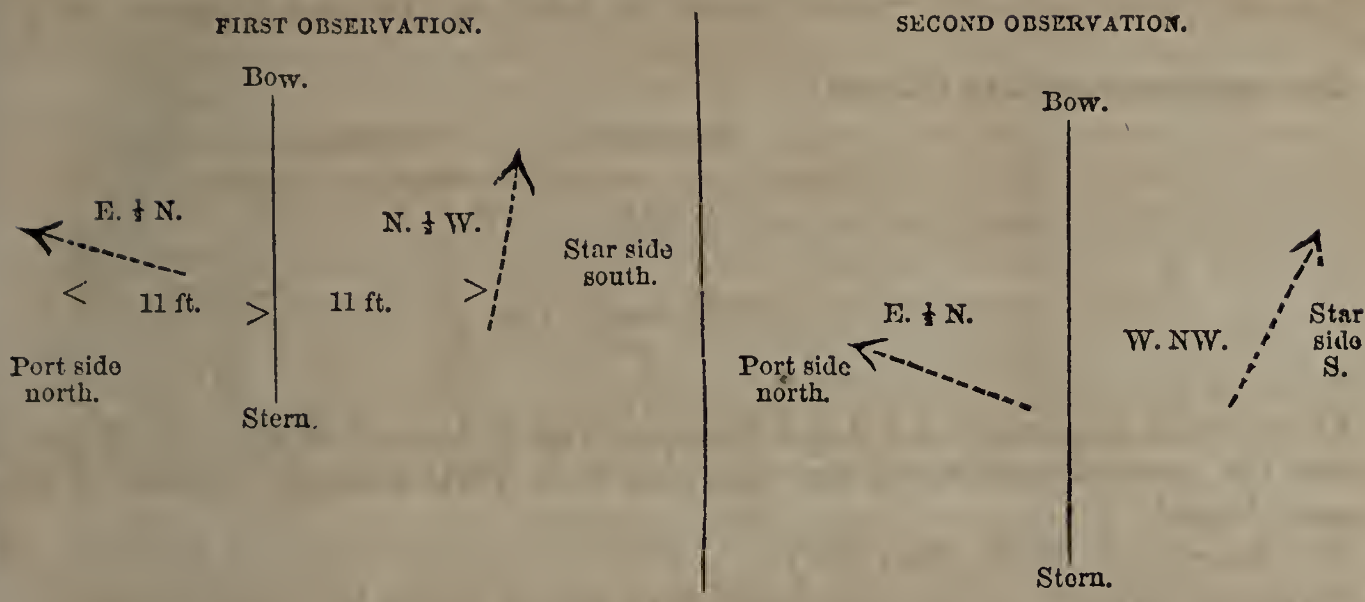
In the afternoon Mr. Frye found that the binnacle compass was so sluggish that nothing could be done with it, and attributed it to the action of the mizzen shrouds, which are of iron and exactly over the compass. He therefore came into town for me to go to the ship and see it. I went on board, and a further examination convinced us that this standing rigging acted powerfully upon it. There were great disturbances on the deck on both sides. There are three shrouds and two topmast shrouds to the mizzen mast.

The following observations show their action:

Compass in Jacob's ladder, 3 feet from deck, and about 6 feet inside of ends of shrouds.

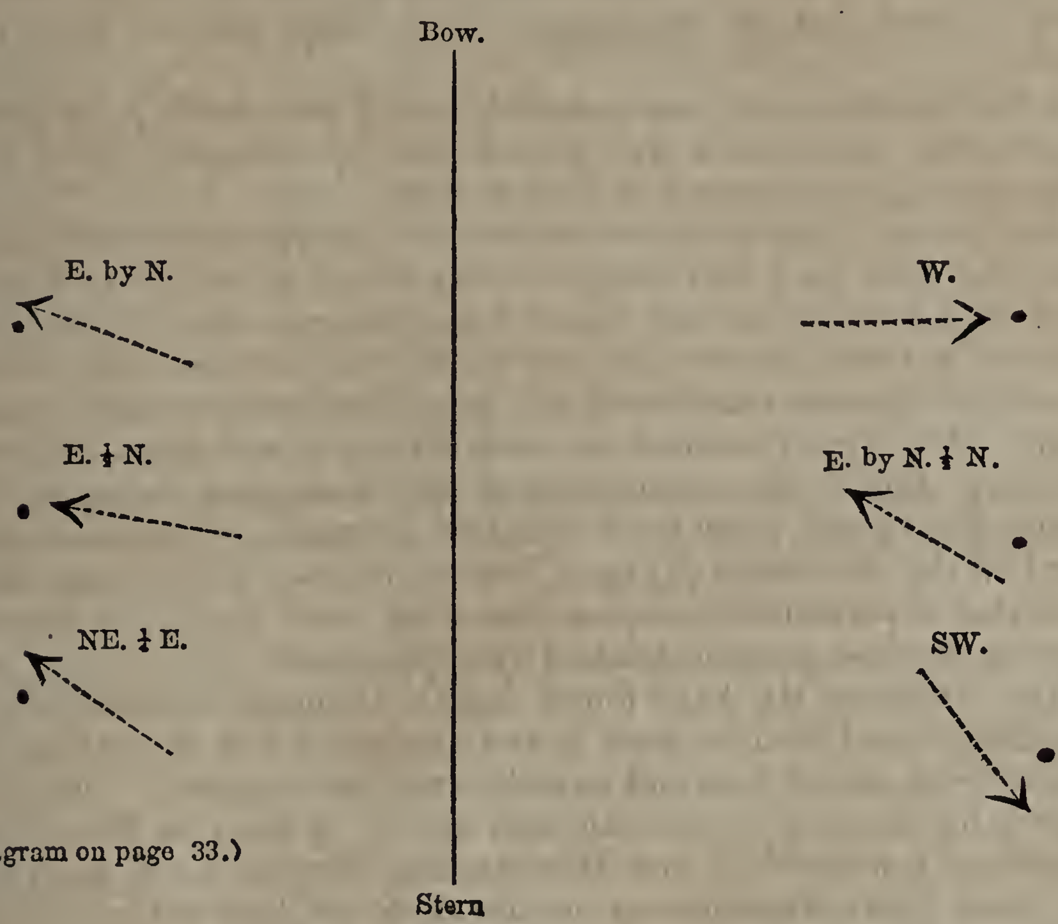
NOTE.—In all the diagrams the position of the arrow represents the direction of the magnetic needle with reference to the ship. The observations were made with a boat compass, and the reading recorded is the reading of the compass when placed with the line joining the centre and the lubber's mark, parallel to the axis of the ship, or, in other words, the bearing of the axis of the ship as indicated by the needle at each point.

SHIP HEADS NEARLY EAST.



Then tried the needle on hammock nettings, opposite to the iron shrouds and about one foot from them, with the following results:

SHIP HEADS NEARLY EAST.



(Compare with diagram on page 33.)

Frye reported to me that the foregoing positions were exactly reversed when the ship headed W. I then met the captain and Commodore Lardner at the house of the latter, and we decided to telegraph to Washington for permission to have the rigging changed, and I directed Mr. Frye to go to New York in the mean time to attend to the Circassian.

Wednesday, June 3.—Drove to League island in the afternoon; did not make any observations, as the rigging was coming down, orders having been received from Washington to have the mizzen rigging changed. Met Professor Bache and Admiral Davis at the Baltimore station at *5h. 15m.*, and explained the matter to them.

Thursday, June 4.—After the wire rigging was removed the captain observed the compasses as the ship swung with the tide, and recorded them as follows:

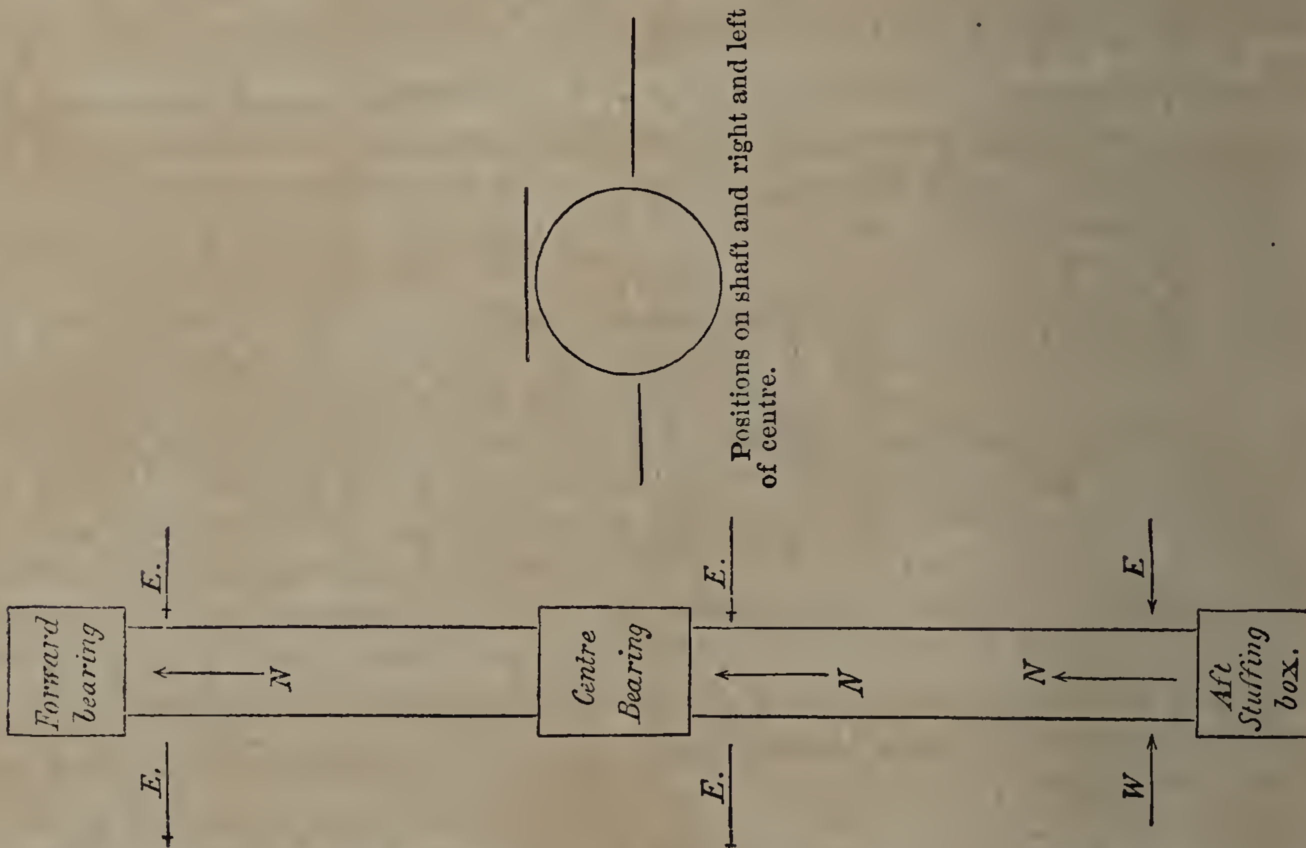
Difference of new standard and binnacle.

Heading N., by standard, binnacle differs		0	
NE.	" "	pt. $1\frac{1}{4}$	to the right.
E.	" "	$1\frac{1}{2}$	"
SE.	" "	1	"
S.	" "	$\frac{1}{2}$	"
SW.	" "	$\frac{1}{2}$	to the left.
W.	" "	$1\frac{1}{2}$	"
NW.	" "	....	

Thursday, June 4.—Frye not having yet returned, I drove to League island, met the captain, and took some shore bearings to compare with reading of new standard and binnacle. They were not very satisfactory, but the heading of the ship by the standard agreed with that taken from the boat.

Tried the propeller shaft, which is 18 feet below the compasses, for polarity.

SHIP HEADS EAST.



Friday, June 5.—Frye having returned last evening, we went to League island at 6 a. m.

7*h*. 27*m*.—Got bearings very carefully with transit instrument from the shore of three points from position of new standard.

Fence at end of Broad street	N. 37° E.
Stake on shore W. of fence	N. 4 E.
Bellevue Hotel, Red Bank	S. 20 E.

Then went on board and determined some bearings with transit from the deck and by the new standard compass, as follows:

8*h*. 0*m*.—By compass in the position for new standard forward of wardroom sky light.

Fence bears	N. 39° E.
Stake	N. 4 E.
Bellevue	S. 17 E.

Ship heads E. $\frac{1}{4}$ S. by new standard.

Ship heads E. by N. $\frac{1}{4}$ N. by binnacle compass.

8*h*. 13*m*.—Difference of a point and a half to the left.

8*h*. 15*m*.—Angle between flagstaff at Fort Mifflin and stake, measured with transit = 107°. Flagstaff therefore bears W. 13° S. true magnetic.

9*h*. 0*m*.—Transit placed in position of new standard, (removed.)

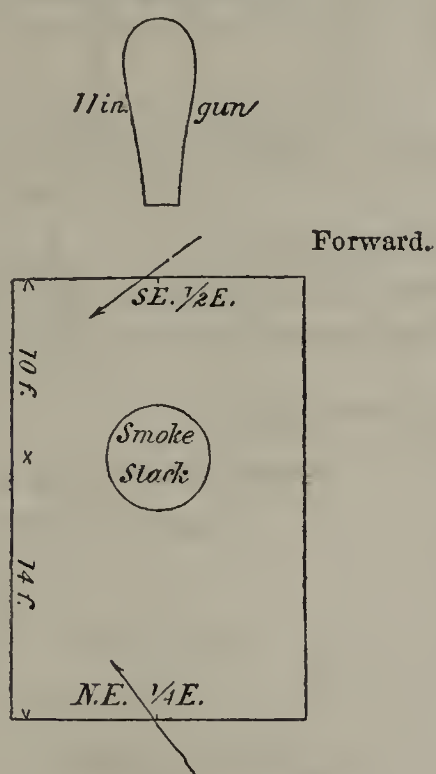
Fence bears	N. 38° E.
Stake	N. 4 E.
Bellevue	S. 20 E.

Ship heads by transit E. 4° N.

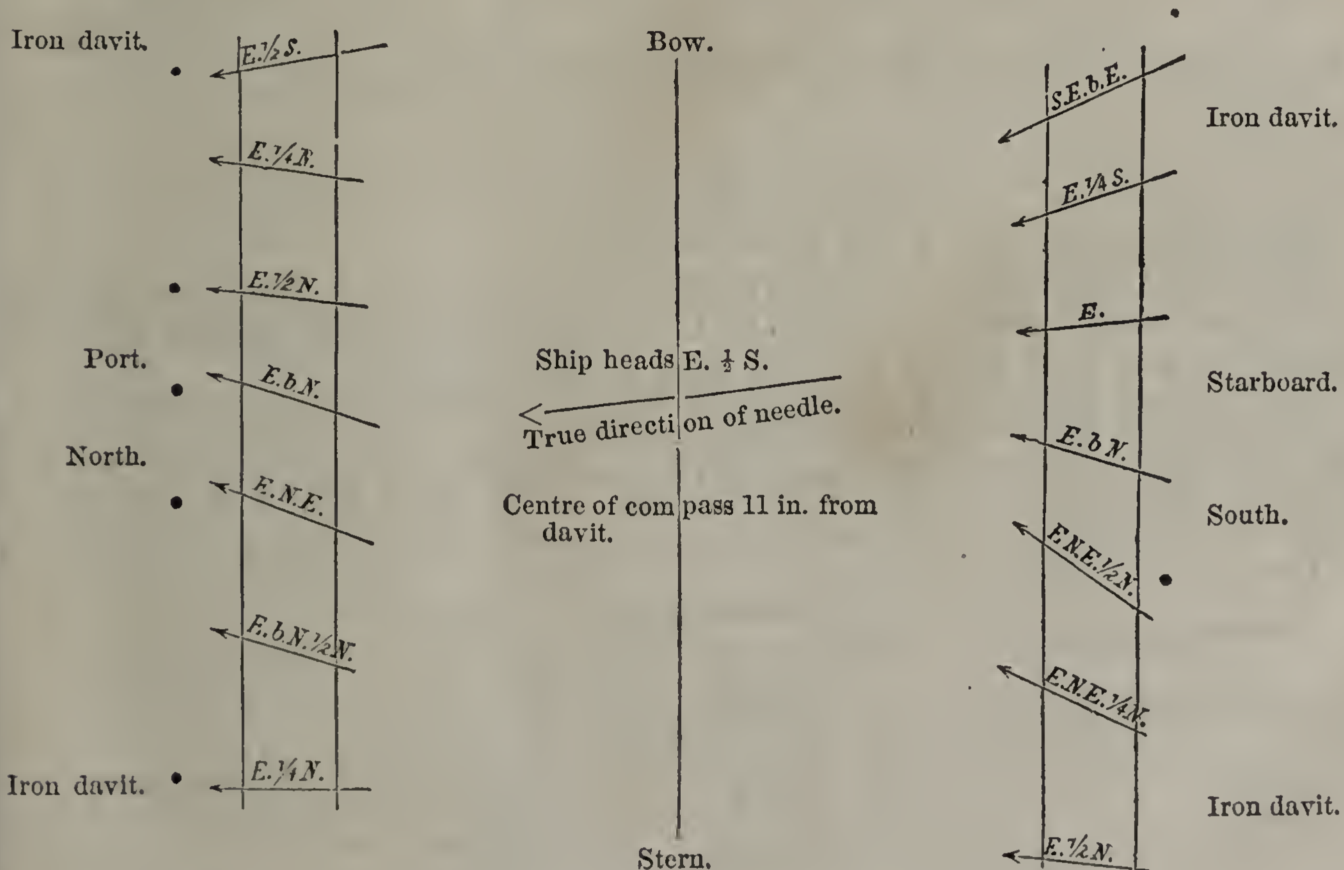
9*h*. 10*m*.—Observed the needle in various positions on the deck, (see sketch I, fig. I,) while ship was heading E. ½ S. The compass was placed on the deck in the points shown in the sketch.

9*h*. 45*m*.—Observed fore and aft of smoke-stack.

SHIP HEADING E.

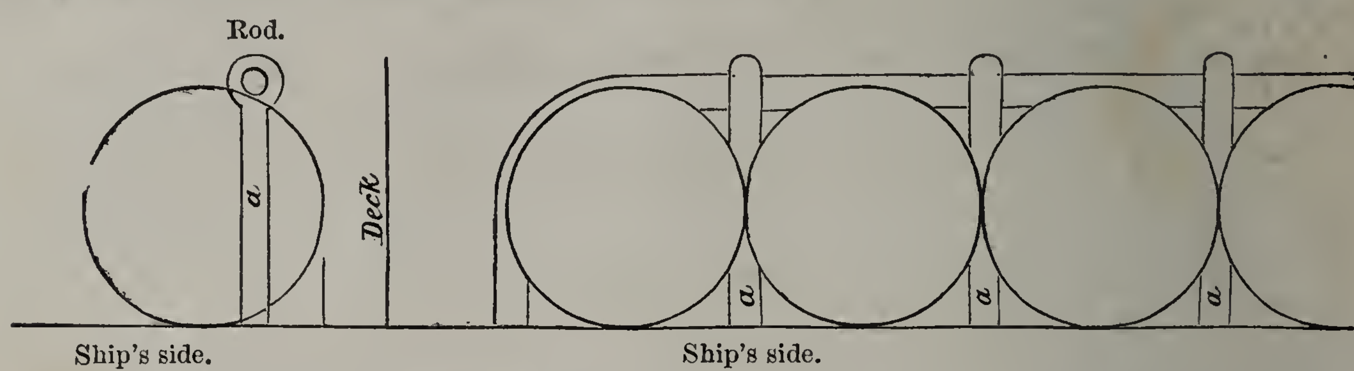


9*h*. 55*m*.—Observed compasses in the same positions in hammock netting at the foot of shrouds, as in experiment on page 31. The hemp rigging being now in place of the wire.



10*h*. 15*m*.—Examined the mizzen-chain plates for polarity. All on both sides showed strong N. polarity at lower end and S. polarity at the upper end. The davits the same. Neutral point of davit was about a foot below position of compasss in last experiment.

On the ship's sides between the lines passing through the mast and through the new standard compass there are five 11-inch shot, (see sketch I,) secured by an iron rod as shown below.

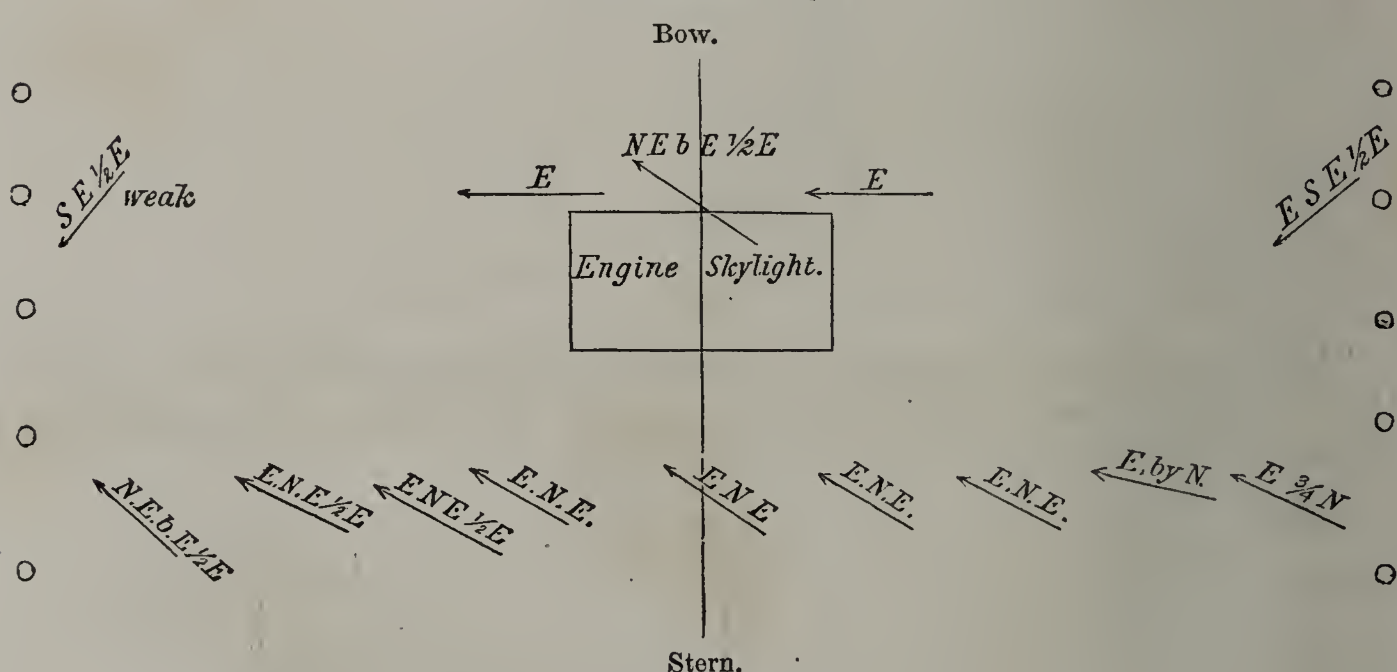


The shot touch each other, and all rest in the rod which is supported by short rods *a*, terminating in eyes through which the large rod passes.

These I tested for polarity.—(See sketch III, figure I.)

Examined ship under main rigging.

SHIP HEADS E. by S.



The compass was held 3 feet above the deck.

11*h*. 0*m*.—Prepared to swing ship on the slack water. Tug came down to help us. Light wind. Ship swinging to the south. Used Fort Mifflin flagstaff, distant one and three-fourth mile, as most distant bearing.

The binnacle compass, which differed one and a half point to the left, north of east on this course, east, was corrected by Mr. Frye by placing four twenty-four-inch magnets in starboard (south) side on the deck, about two feet from centre of the compass, lying fore and aft, the north poles all together and aft or west.

	New standard.	*Binnacle.*
11*h*. 50*m*.	E.	E.
	E. by S.	E. by S.
12 00	E. SE. ½ S.	E. SE. ½ S.
12 03	SE. by E. ¾ S.	SE. by E. ½ S.
	SE.	SE. (Standard proved.)
12	S. SE.	S. SE. (by flagstaff range.)
14	S by E.	S. by E. (W. by S. ½ S.)
	S.	S. (Standard correct.)
18	S. by W.	S. by W.
	S. SW. ½ W.	S. SW.

0h. 25m	SW. by S. ¼ W.	SW. by S.
	SW. by S.	SW. by S.
35	SW.	SW. (Wanting 2°.)
1 30	W. SW. ¼ W.	W. SW.
2 12	W.	W. ½ S.
20	W.	W.
31	W. by S.	W. by S. ¼ S. (Standard correct.)

In all these comparisons the binnacle was sluggish, and even when recorded as reading the same as the standard, it was generally one or two degrees behind it or to the left.

2*h*. 46*m*.—The ship heading westerly, observed the polarity of cannon balls, see sketch III, fig. 2.)

4*h*. 10*m*.—Observed compass on the same points as at 9*h*. 10*m*., (see sketch I, fig. 2.) See sketch II for the reduction of these observations to due E. and W.

4*h*. 30*m*.—The tide again serving, prepared to swing ship from W. to E. by the north to complete the circle. Tug assisting by hawser to stern.

4*h*. 55*m*.—Ship heading W., the standard (new) was correct by flagstaff range.

	New Standard.	*Binnacle.*
4*h*. 55*m*	SW. ½ W.	SW.
	W. SW. ¾ W.	W. S.W. ¼ W.
	W ½ S.	W. by S.
	W.	W. ½ S.
	W. ½ N.	W. ½ N.*
5 15	W. ¾ N.	W. ½ N.
	NW.	NW. ¼ W.
	NW. ¼ W.	NW.
	N. NW.	NW. by N. ½ N.
	N. ½ W.	N. ¾ W.
	N.	N. ¼ W.
5 23	N ½ E.	N. ¼ E.
	N. by E.	N. ¾ E.
5 25	N. NE.	N. NE.
	NE. by N.	......
	NE. ¼ N.	NE. ¼ N.
	NE.	NE.

	New Standard.	*Binnacle.*
	NE. ½ E.	NE. ½ E.
5*h*. 27*m*	NE. by E.	NE. ¾ E,
	NE. by E. ¼ E.	NE. by E.
	E. NE.	E. NE. ¼ N.
	E. by N.	E by N. ¼ N.
	E.	E. ¼ N.
	E. ½ S.	E. ½ S.
	E. by S.	E. ¾ S.
	E. by S. ½ S.	E. by S. ¼ S.
	E. SE.	E. SE. ½ E.
	SE. by E.	SE. by E. ¼ E.
	SE.	SE.
	S. SE.	S. SE. †
	S. by E.	S. by E. ¼ E.
	S. ¼ E.	S. ½ E.
5 40	S.	S. ¼ E. †

* Shifted the magnets so as to reduce this error about 2°, and so average it with error on S. course.
† Standard correct.

The standard was proved at intervals through all the series. When the ship reached this point, south, at 5*h*. 40*m*., the tide became too strong and we had to stop and let her swing back to east. The magnets were then finally secured and covered.

The observations showed that the standard compass worked well and agreed with the shore bearings; that the binnacle had a constant error to the left of a quarter of a point, in all courses, and nearly one-half of a point at west. Even where the same reading is recorded for both compasses, the binnacle was always a little behind to the left of the standard. Upon a careful examination we found that the binnacle did not stand quite squarely upon its stand, and that the lubber's mark was not in the axis of the ship, but about a quarter of a point to the left. Turning the binnacle into the proper position eliminated the constant error of the quarter point. We had before reduced the error in the west course by approaching the magnets to the binnacle, so that, as far as we could say, without having an opportunity to swing again all round, the binnacle agreed very nearly with the standard in all courses. The binnacle compass is, however, very sluggish, and requires tapping and coaxing to cause it to take its proper place. Under steam we suppose that this will be better.

Is is a matter of much regret that the necessity for the departure of the vessel prevented further investigations.

FAIRMAN ROGERS.

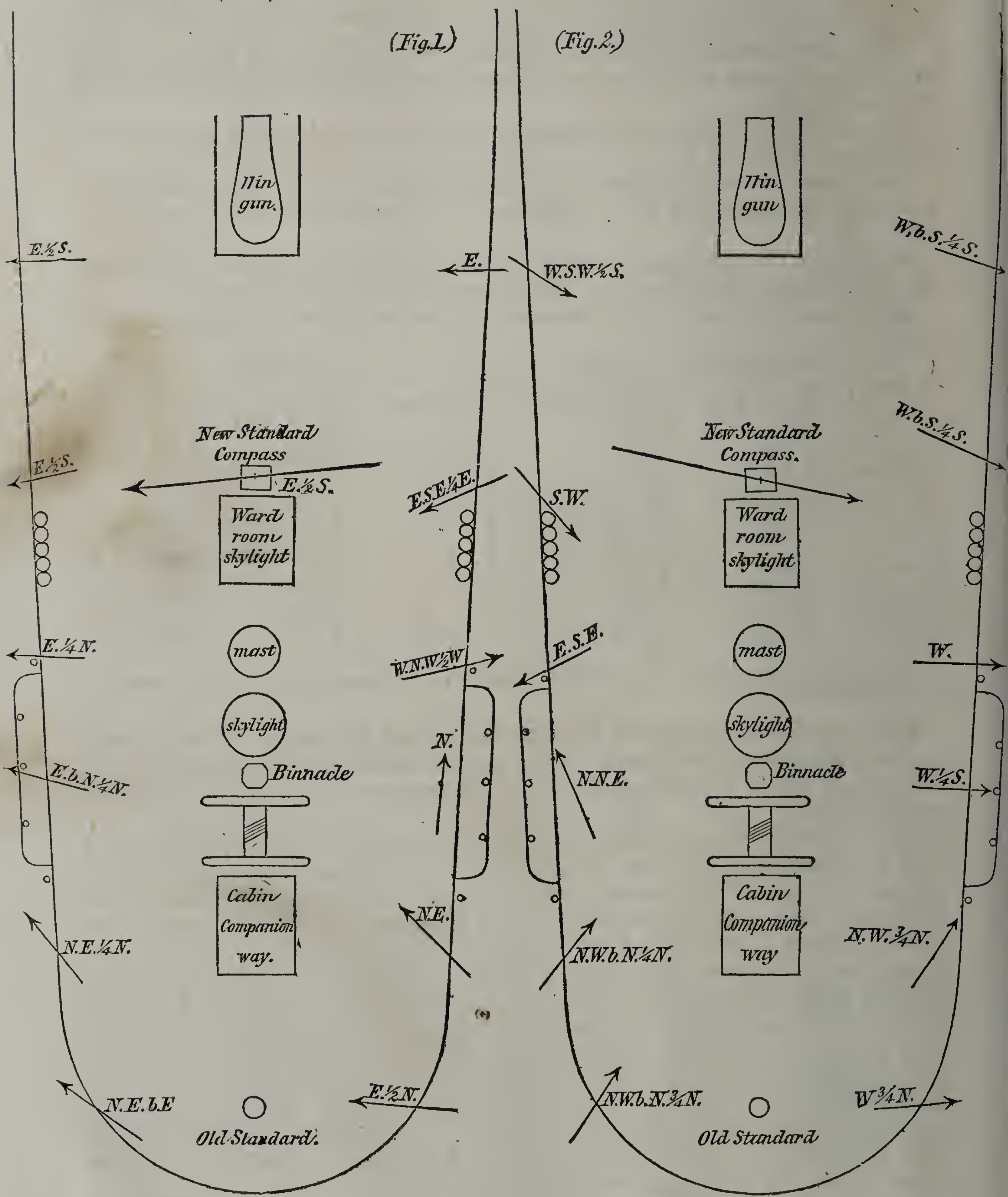
PHILADELPHIA, *June* 1863.

SKETCH I.

June 5, *a. m.*—Ship heads E. ½ S., true magnetic, as observed.

June 5, *p. m.*—Ship heads W. by S., true magnetic, as observed.

TICONDEROGA, *June*, 1863.

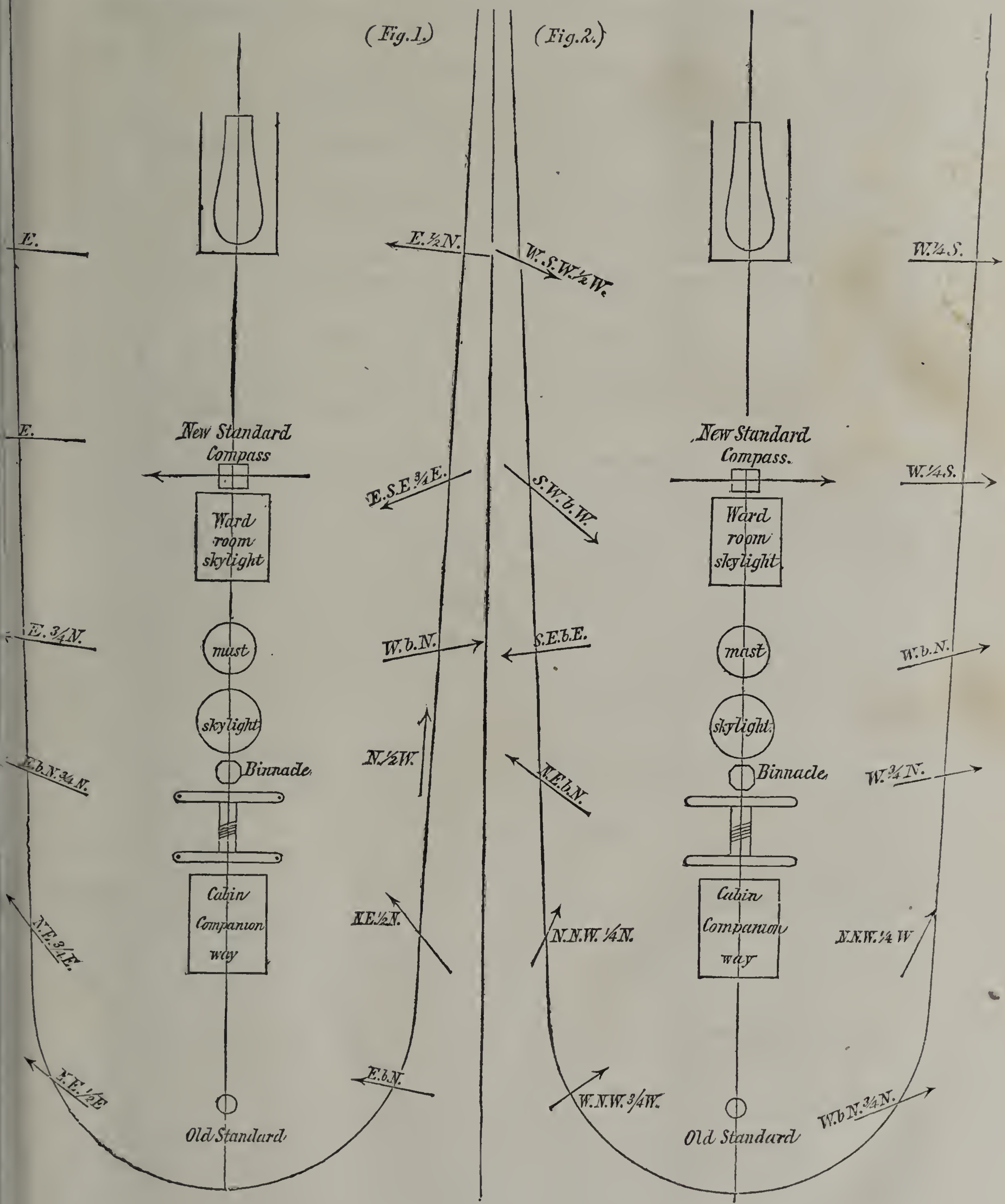


SKETCH II.

Ship heading due E., magnetic, adjusted for due E. from Sketch I.

Ship heading due W., magnetic, adjusted for due W. from Sketch I.

TICONDEROGA, *June*, 1863.

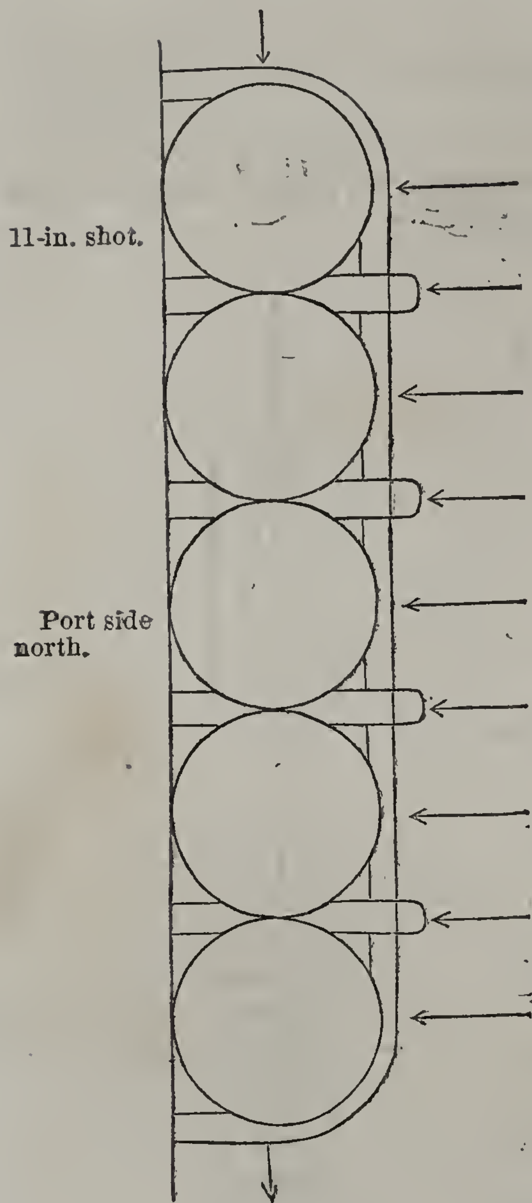


SKETCH III.

FIG. 1.

TICONDEROGA, *June*, '63

Ship heads E.



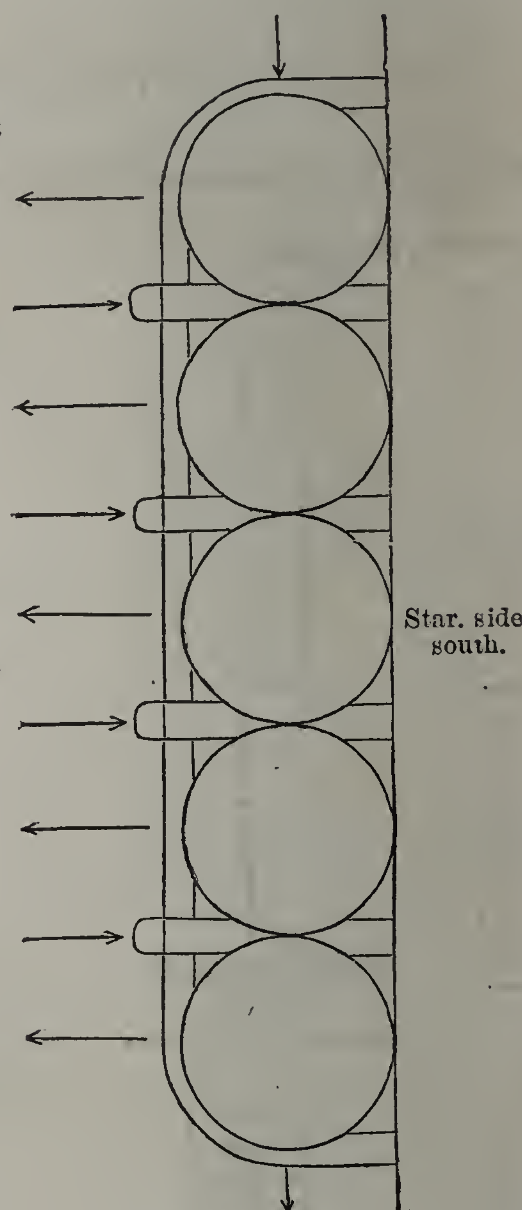
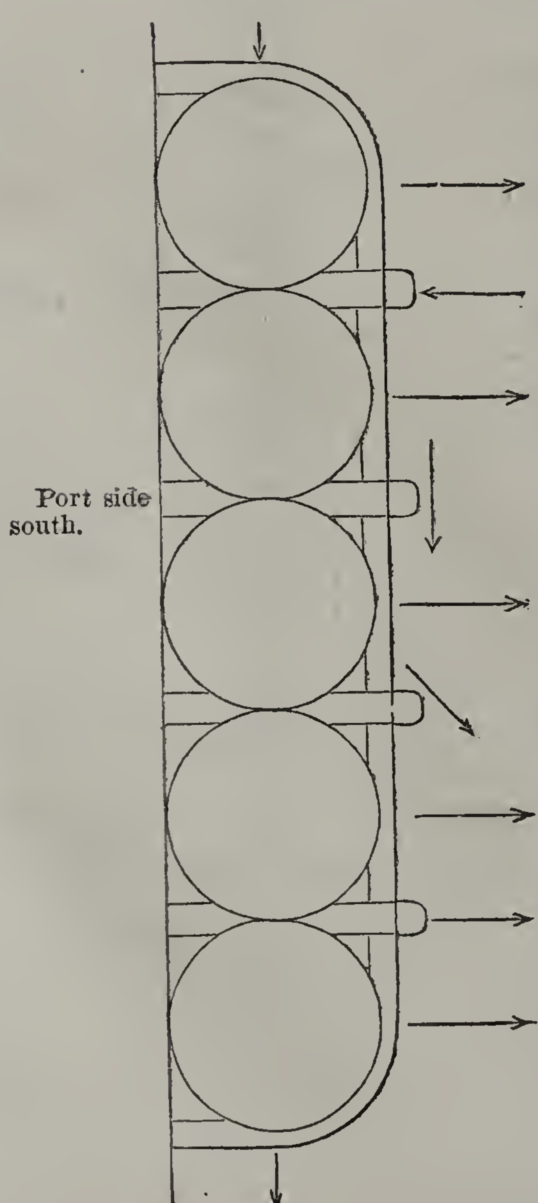
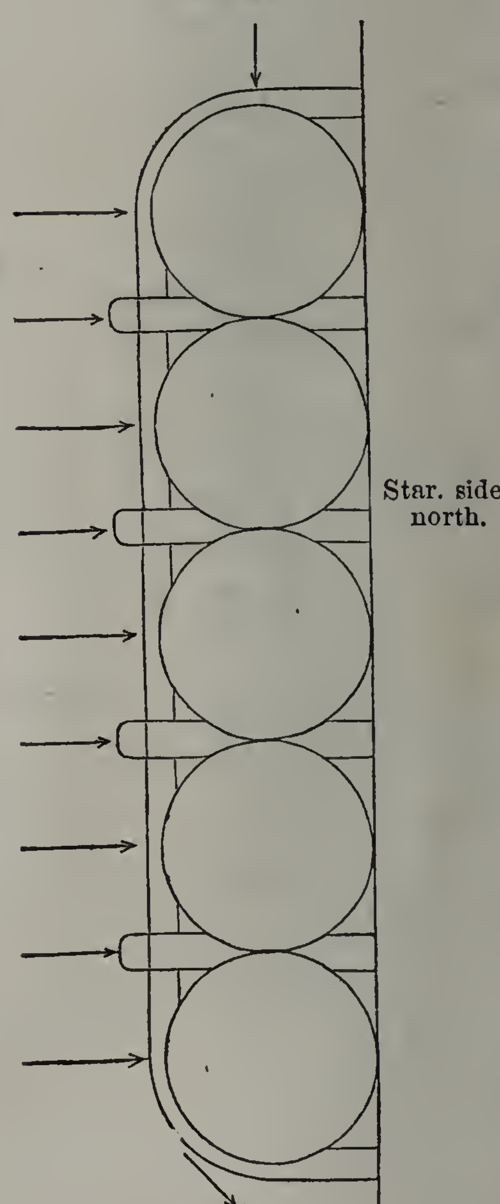


FIG. 2.

Ship heads W.





APPENDIX No. 3.

Report to Professor Bache, chairman of compass commission, United States navy, on the adjustment of compasses for local attraction on board the following naval steamers:

The prize steamship Circassian, adjusted at the compass buoys, Sandy Hook, March 23, 1863.

Experiments on the monitor Roanoke, commenced March 28, 1863, with a view to the best positions for arranging the compasses. Every part of the ship was carefully examined, and, notwithstanding the ponderous weight of iron of which her three turrets, her iron deck, and iron-clad sides were composed, it was found practicable to arrange a compass on either of the turrets, or in the cabin or wardroom of the ship, by using bar magnets to overcome the deviation when the ship was heading east or west. The errors on north and south courses having been found very small, a tell-tale compass has been screwed up, under the iron deck, in the cabin, and corrected with a bar magnet, and is found to work so well that it is the standard compass of the ship. This arrangement might be much improved by cutting a hole in the deck and putting in a plate glass, protected by an iron cover, to be removed when the compass is needed, in the same manner that the deck lights are protected. The covers are made to screw on. In this manner the compass could be seen on deck as well as below when needed.

The United States gunboat Sunflower, the next vessel adjusted for local attraction. She was bound for the Gulf squadron, from Boston. Captain Van Sice, finding no reliance could be placed in his compasses, put into New York and applied to the department for permission to have his compasses adjusted for local attraction. The work was completed at the compass station, Sandy Hook, May 11, 1863, from which place she proceeded to sea, and, on her arrival at Key West, Captain Van Sice wrote me a letter stating that his compasses had performed admirably ever since I had adjusted them with bar magnets. They had before some four points error on some courses. Her steering compass was only six feet forward of boiler and six feet aft the large pivot gun. The aft standard compass was similarly located, being but six feet aft the engine and six feet forward the aft pivot gun. Enclosed I send you a copy of the letter I received from Captain Van Sice on the performance of her compasses after correction.

The United States naval steamship Ticonderoga, the next ship adjusted, at League island, June 6, 1863. Diagrams showing the position of compasses and adjusting magnets were forwarded at the time. The Ticonderoga was constructed of wood; her standing rigging was wire rope, the mizzen rigging being exactly over the compasses, she having two binnacles, standard and port. The errors on east and west courses were large. I directed the binnacles to be rigged amidships, one at the wheel, and the other was carried forward twelve feet for standard compass. Hemp rigging was substituted for the wire, the compasses corrected with magnets, after which they worked well.

United States navy prize iron gunboat Adela, Captain Stodder, adjusted at the station, Sandy Hook, June 13 and 14, 1863. She was built in Europe, and had been formerly adjusted on Airy's plan. Part of her old magnets were found to be in good condition and were rearranged. The work was done in great haste, and the ship went to sea from the compass moorings. She was ordered to the Gulf, and after an absence of several weeks returned to New York. I made inquiry of the commander, Captain Stodder, who addressed me a note on the subject, a copy of which I enclose.

United States prize iron steamer gunboat Granite City. She was built in Europe, and had been adjusted on Airy's plan, but the magnets had been

removed. We took her to the compass station on the 28th day of July, but did not complete the work until the evening of the 31st, owing to very heavy weather.

United States prize iron steam propeller Gertrude. This ship had been formerly corrected on Airy's plan. The magnets had been taken up; but, being of excellent quality and cased in copper, they appeared to have retained their original strength, and I used them in adjusting her compasses. The binnacles and compasses were of excellent quality, the needles highly charged, the bowls suspended on rubber springs—an excellent plan to overcome the jarring motion of the propeller. The work was completed on the first day of August, and diagrams forwarded at the same time or soon after. The Gertrude sailed for the Gulf of Mexico, and I have not heard from her since that time.

United States army tug-boat the Rescue. At the request of Mr. G. W. Blunt, I went to Jersey City on Thursday, August 6, (Thanksgiving day,) and adjusted the compass, which was placed over the end of a 20-foot cylinder boiler, elevated only three feet above the boiler. Diagrams of the work were forwarded.

The monitor Roanoke, adjusted at Hampton Roads, August 13; mentioned in the first part of the report. Drawings were forwarded to your address.

Quaker City, adjusted at the compass station at Sandy Hook, August 19. She was constructed of wood. The errors of her compasses were caused by her armament mainly—diagrams showing the position of compass aft and the guns. The forward standard compass was deranged by the engine and smoke-pipe, as the drawings will also show.

United States prize iron gunboat Aries was the next vessel operated on. The work was done in great haste, owing to peremptory orders for the ship to proceed to sea at once. A card of deviations was furnished, and Commander Devens promised to have the work completed on his arrival in New York. This was on the 23d of August.

United States steamship Fort Jackson was the next in turn. The Fort Jackson was a wooden ship, side-wheel. Her steering compass was arranged in a very unfit position, and I felt it my duty to condemn the position as unfit for steering compass. The error was large—nine points on east and west courses—and the polarity was feeble. I beg to refer you to the drawings which I forwarded at the time, which will give you a tolerably correct idea of the compass and the surrounding difficulty. The work was finished September 2, at compass station, Sandy Hook. She went immediately to sea, encountered a severe gale, and has returned to New York somewhat damaged; and I presume a better place will be selected for her steering compass before she again goes to sea. Captain Alden reports three-fourths of a point extreme error.

United States prize iron steamer propeller Bermuda; her compasses adjusted at League island. The work was completed September 7. The binnacles and compasses were of the best quality, well planned, and of excellent workmanship. One of the binnacles had 8-inch painted cards and knife needles, strongly charged; the bowls and rings were heavy, the shoulders stout and firm; the bowls were suspended on rubber springs to prevent any jarring motion of the ship's affecting the compass, and the cards were gymbal with bell centre. The hood over the binnacle was furnished with lamps and finely arranged. If Mr. Blunt would adopt this hood on his brass binnacle it would make it complete. Only one of the compasses was adjusted; the other is to have a place built for it forward of the smoke-pipe. All of the old magnets were found on board, but were very badly rusted; they had been packed in wooden boxes and not cased in copper. Only one of them was in condition for use; the others have been repolished and put away for the other binnacle. Drawings have been forwarded.

United States navy steam propeller Shenandoah. I received a letter from

you, dated June 21, 1863, directing me to overhaul this ship upon her arrival at Boston. On the 2d day of September I examined the compasses, and found two points error, owing in part to wire mizzen rigging, she having twin binnacles arranged starboard and port. After an explanation of the matter with Captain Ridgely, one binnacle was carried twelve feet forward, placed amidship for standard compass; the other rigged amidship, in front of the wheel, for steering compass. Owing to some derangement in her machinery she could not then go to the compass station; and, my services being wanted in New York, I returned, hoping to join the Roanoke before her departure for Hampton Roads, but was about one hour too late. On the 31st of August I received a letter from the executive officer of the Shenandoah, dated at Philadelphia, requesting me to come on and finish the adjustments of the compasses. On the 1st of September an order came from the Bermuda, at Philadelphia, and I reported for both ships. The Shenandoah was swung at League island, September 8, when it was found that the change of position of binnacles had proved perfect compensation for the errors in the former position. No magnets were required in this case. This case should teach us to select proper positions for the compass in the early stages of the ship's construction. The experience of many years has convinced me that it is one of the last things thought of. I think some reflections on this point might result in laying down rules for the guidance of the constructor. I am aware that the constructor can point you to hundreds of cases where he can say they got along very well; but what necessity is there for placing a compass in such positions as those on the Ticonderoga, Fort Jackson, and Shenandoah. Had this matter received earlier attention, delay, risk of life and property, to say nothing of the expense, might have been avoided, or, at least, partially remedied. The fault in the arrangement of the Shenandoah was in placing two binnacles abreast; the case of the Ticonderoga was the same.

United States iron transport Karnak, built in Europe. By request of Mr. G. W. Blunt and the owner, Mr. Kimble, I went on board the above-named vessel at Jersey City, September 22, and rearranged the binnacle and magnets, which I found were on Airy's plan. The ship had been sunk at Nassau. The magnets had part of them been taken up, and one new binnacle had been furnished by Mr. Blunt—a metallic binnacle. The ship was lying at the dock, coaling, and soldiers were coming on board, and the ship was to leave on the same evening with the troops.

After I had arranged the magnets, the compass agreed with the bearings on shore. The ship was heading west 5° south, and as I had placed the magnets precisely in the same position, I concluded they had lost none of their power, or it would have been necessary to place them nearer the binnacle. On leaving the ship in this condition, the captain promised to have her swung upon his return to New York.

United States gunboat Paul Jones, constructed of wood, a double-header, 800 tons, was the next vessel operated upon. She sailed for the compass station at Sandy Hook, September 26, and first swung to note the original errors of the compasses, which were found to be two and a half points on east and west courses. Polarity rather feeble, owing to the peculiar situation of the compasses. The aft steering compass was arranged over the aft part of the engine, and about ten feet forward of the large pivot gun. The local attraction was found to be very strong, causing the needle to move more sluggishly. I applied the bar magnets in the usual manner, but the compass did not work well; notwithstanding I had nearly neutralized the local attraction, the compass was still sluggish and did not settle well when agitated, showing a want of directive force. The standard compass was arranged on the hurricane deck over the cylinder, the piston-rod passing forward and back, bringing the crank within about three and a half feet of the compass. Immediately under the deck

were arranged the muskets and cutlasses, and opposite were the side wheels, the rims of which were five feet above the compass. All these bodies of iron, from their close proximity, seemed to combine to distract the needle, which, like the steering compass, was sluggish, and would not settle at all times alike. Finding it necessary to abandon both of these positions, I went forward of the smoke-stack and selected a new position, which I examined with great care, and found that a compass in this position would work well. I recommended that a pilot-house be erected there, and it was thought prudent to return to the navy yard and have the alteration made. Mr. Delano, the constructor, took the matter in hand, and by working all night the work was completed the next day; and, upon swinging the ship again at the compass station, the compass was found to work perfectly well without the use of bar magnets. The work was commenced on Tuesday morning, and on Wednesday evening the ship went to sea. Diagrams showing the position of the compasses are enclosed.

The following is a list of vessels on which I have adjusted compasses for local attraction since the 23d day of March, 1863:

March 23	Circassian, (iron prize.)
March 28	Roanoke, (iron-clad.)
May 11	Sunflower, (wood.)
June 6	Ticonderoga, (wood.)
June 14	Adela, (iron prize.)
July 28	Granite City, (iron prize.)
Aug. 1	Gertrude, (iron prize.)
Aug. 6	Rescue, (tug, wood.)
Aug. 13	Roanoke, (wood, iron-clad.)
Aug. 19	Quaker City, (wood.)
Aug. 23	Aries, (iron prize.)
Sept. 2	Fort Jackson, (wood.)
Sept. 7	Bermuda, (iron prize.)
Sept. 8	Shenandoah, (wood.)
	Douro, (private, iron prize.)
Sept. 22	Karnak, (charter, iron prize.)
Sept. 26	Paul Jones, (wood.)

List of vessels which have been reported to me, now fitting out at the Brooklyn navy yard, but not yet ready to have their compasses adjusted. Most of them are iron prize vessels, built in Europe. I have made surveys on all of them, and have in every case found that they had been adjusted on Professor Airy's plan:

Virginia, (iron prize.)
Seminole, (wood, gone to sea.)
Peterhoff, (iron prize.)
Merrimack, (iron prize.)
Emma, (iron prize.)
Neptune, (iron prize.)
Buckingham (wood.)

REMARKS.

It is worthy of remark that, notwithstanding there are several modes recommended in Europe, as well as at home, for overcoming local and other attraction on iron and other ships, I have never found any other than the bar magnets in use in all the ships I have examined; nor have I ever examined an English iron ship, since 1844, where I did not find them in use. The Guadeloupe, captured by Commodore Moore during the Texan war, was among the first which I readjusted, and from that date to the present time, including the thirteen modern-built prize steamers named in this report, I have found no material change in the mode of applying them. There are probably other modes in use, but the percentage must be small, as I have never encountered them in all my experience since I commenced my experiments in 1842, with a small iron model

ship placed on a revolving table, furnished with miniature compass and bar magnets, with a north and south line (magnetic) drawn through the room. I commenced my experiments and continued them up to June, 1844, when Captain Ottenger, of the revenue service, was directed by the Secretary of the Treasury, R. J. Walker, to superintend a series of experiments with heavy iron binnacles, which some one had recommended; also iron compass bowls, recommended by Mr. Ericsson; and to examine other plans, such as packing the compass in zinc cases stuffed with charcoal, which was more ridiculous than the old sailor's iron pot. The iron binnacle was thirty inches high, four inches thick, and weighed about 600 pounds. All proved to be fallacious and forever cast away, and resort was made to bar magnets. On the report of Captain Ottenger, the department gave me the Legare to adjust, saying, if satisfactory, others would also be adjusted in the same way. The work was completed on the 16th day of June, 1844, at the Atlantic dock, Brooklyn. The ship went on a cruise, and on her return made a favorable report on the performance of her compass; upon which the department decided to give me an appointment to attend to the other seven vessels then building, which were all completed in 1847; and on the 27th day of April, 1848, I was presented with a diploma, written on parchment and bearing the seal of the treasury of the United States, of which the following is a copy:

UNITED STATES TREASURY DEPARTMENT,
Washington City, D. C., April 27, 1848.

This will certify that Mr. A. D. Frye, of the city of New York, has been employed by this department in correcting for local attraction the compasses on board of the iron revenue steamers McLane, Dallas, Legare, Spencer, Jefferson, Bibb, Polk, and Walker; that, from the reports of the proper officers, the operations have been eminently successful; and that, as far as the experience of three years has exhibited, the corrections are permanent where the original disposition of armament, steering apparatus, &c., has been preserved.

M. C. YOUNG,
Acting Secretary of the Treasury.

Since 1842 I have adjusted compasses for local attraction on seventy-five steamers and other vessels. Visiting so many government vessels as experimentalist to the United States naval compass commission, I have had opportuties of learning much from officers of the navy, pilots, and others, and I find an earnest desire on the part of young officers to obtain a knowledge of the phenomena of the magnetic needle, and the various remedies for overcoming local attraction on board of ships. They often ask, what makes the needle point to the north, and whether we cannot cut off local attraction, and even point to cases where it has been done, or they had been told so. Inquiries are often made for books and documents on the subject; they want information, and freely confess their ignorance on the subject.

The introduction of steam-engines and boilers on board ships has deranged the needle. Ships built entirely of iron cannot have a perfect working compass on deck without some arrangement to overcome local attraction. The iron steering wheel should be condemned, for I know it can be made of composition and be equally strong by working it a little stouter. I need not say to you that the iron screw steering apparatus is within twenty-four to thirty inches of the compass card, five feet long, shaft three inches thick, and at the same elevation of the compass. Attempts have been made, both here and in Europe, to cry down the bar magnets by interested parties, but they have all failed to bring forward anything better, or even as good, that I have yet seen or read of.

The compass carried aloft, or elevated on the mast, as I have often seen them, say from ten to fifteen feet, are not always popular. They say they were of no use in thick weather, or in heavy gales, when the ship was plunging heavily. Local attraction exists aloft as well as on deck. Tall smoke-stacks, wire-rope rigging, chain stays, &c., all require examination for local attraction, as well as

position on deck. In answer to my inquiries, in some cases, I am told, "We had a compass elevated, but it did no better than the one on deck, and was always in the way when handling the rigging or sails."

Where compasses are adjusted for local attraction, I think they should be examined once a year, or oftener, by swinging the ship at the compass station, and rearrange the magnets if necessary.

Navigating a ship with a table of deviations when the errors are large is not always reliable, and the ship must be swung to make a table of errors, and it will take no more time if you put down the magnets at the same time; and if they are laid with care, they will always reduce the large errors, say three points to less than one-half point; and this will relieve the card from hanging when you change your course, and also relieve the compass from changes in the magnetism of the ship, or, in other words, local attraction of the ship.

Under the most unfavorable circumstances, it is best to use the magnets, for there is no case that I have yet seen recorded where the needle has gone back to the original errors with the magnets still in position, nor do I think it possible for such a case to occur.

A. D. FRYE.

APPENDIX No. 4.

Record of magnetic observations taken on board the Roanoke at the Brooklyn navy yard, June 5 *and* 6, 1863, *by G. W. Dean and Charles A. Schott, assistants United States Coast Survey.—Report with results by C. A. Schott.*

INSTRUMENTS.

For the examination of the relative horizontal intensity a Gaussian deflecting apparatus had been provided, consisting of a small magnetic needle with a portion of an arc divided to 15° either way from the central index, and a scale divided from the middle to both ends from 0 to 50, (nearly centimetres;) each deflecting magnet was ten divisions in length and one in breadth; a small wooden stand, with spirit level to secure its horizontality, was used as a support. When the range of the divided arc was insufficient, a larger compass was used for placing the instrument in position.

The relative total intensity was determined by means of a dipping circle (C. S. No. 8) provided with position and Lloyd needles. The polarity of the turrets was examined with a small pocket compass, (the size of a dime,) and the bearings were taken with an ordinary azimuth compass, and one of Würdemann's prismatic azimuth compasses.

METHOD OF OBSERVATION.

The relative horizontal intensity observations were made in the usual manner, (as described by Dr. Gibbs in a paper accompanying the instruments.) When practicable the deflections were noted with the bar magnet at three distances from the needle, viz: 30, 40, and 50 divisions. The needle was also deflected through the arc of local deviation, and the distance noted. Nine positions had been selected on deck and were marked with copper tacks, six stations near the sides of the vessel at four feet distance each; one station nearly amidships, one at the stern, and one at the bow in the longitudinal axis of the vessel. The necessary measures of length for the relative positions of these stations were taken. The angle of local deflection at each station was ascertained by reciprocal bearings with suitable shore stations in positions which appeared most free of any effect of iron in the vicinity. Deflections were made with the scale

at right angles to the magnetic meridian, and in the magnetic meridian. The bearing of the axis of the vessel was determined from a shore station, supposed to be uninfluenced by any local attraction; bearings were also taken on board at various elevations above deck. The dip circle was mounted over each of the nine stations for the usual dip observations in (what may properly be called) the apparent magnetic meridian, with the Lloyd needle, one set without and one set with a pin weight; one station was occupied for comparative results, where also the dip was observed with two position needles, Mr. Halter assisting in these observations.

The distribution of magnetism of the turrets, as far as the tracing out of the kind of polarity was concerned, was ascertained by means of the co-ordinates of those points where the polarity was found to change.

The great number of workmen, and especially the coaling of the ship, interfered much with the prosecution of the observations on the first day, while on the second day the examination of the inside of one of the small top turrets was found impracticable on account of fresh paint; painters were engaged in the inside of each of the large turrets all day.

You are already aware that the turrets could not be revolved, nor could the vessel be swung, on account of too great an interference with the workmen. The examination of the changes in the deviations, and the intensity in various azimuths of the ship's head, remain, therefore, to be ascertained. With greater facilities, at another time, the polarity of the hull outside and inside, as well as the intensity inside, might also be examined.

June 4 was spent in getting the instruments on the ground, in their examination, and having a stand made; also in preparing a scheme of work for the following days.

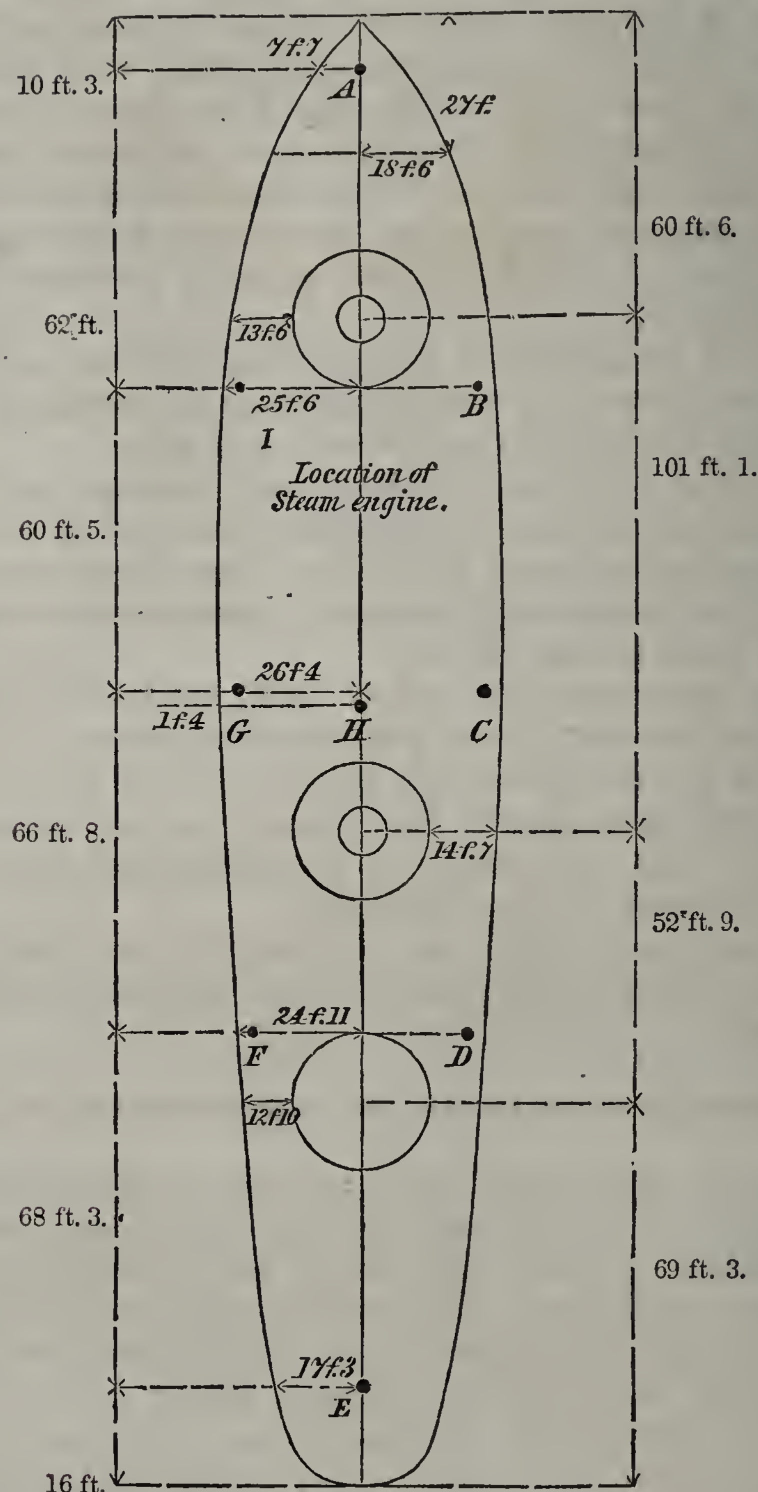
SELECTION AND MEASURE OF THE STATIONS ON DECK.

June 5.—To secure uniformity, all observations for deflections were taken at the uniform height of one foot and half inch above deck, which consists of 3-inch outside planking, $1\frac{1}{2}$-inch iron plating, and a second inner planking, altogether $9\frac{1}{2}$ inches in thickness. The stations near the sides are four feet from the outline, the sides have $4\frac{1}{2}$ inches of iron plating above water, and $3\frac{1}{2}$ inches below the water-mark, backed by 26 inches of timber, (as we were informed by workmen.) These stations were selected so as to keep out of range, as far as practicable, of large masses of iron, such as the turrets, anchor, rudder, boat davits, &c.

The outline of the deck of the Roanoke, with the position of the turrets and the stations A, B, C, D, E, F, G, H, I, are shown in diagram (A,) drawn to scale.

All measures are expressed in feet and inches. The three turrets are of the same size, viz: 72 feet circumference, (23 feet diameter;) the small top turrets are 23 feet circumference, ($7\frac{1}{2}$ feet diameter.)

A.



RECIPROCAL BEARINGS TO FIND LOCAL DEVIATION AT EACH STATION.

The Würdemann prismatic compass was placed successively over the stations and simultaneous and reciprocal bearings of the two compasses (the second one on shore) were taken. The shore compass had to be moved to five different places, most probably free of local attraction. No one suitable point on shore could be found where all the stations would be intervisible. The bearings of the prismatic compass count from S. round by E. to 360°; those by the other compass are counted from N. or S. towards E. or W. In all cases the needle on board was 1 foot ½ inch above deck.

Bearing of head of Roanoke (longitudinal axis) S. 28° E., taken from a selected place on shore about 100 yards from stern. She remained, with small fluctuations, in this direction during the two days of experimenting.

Comparison of the two compasses at shore station, bearing of a distant chimney:

	1st set.	*2d set.*
By Würdemann compass	S. 177¾° E.	S. 177[illegible]° E.
By ordinary compass	N. 2 E.	N. 2¼ E.
Difference	¼°	°

No correction was therefore applied to the reciprocal bearings.

Station on board.	FIRST SET. Bearing of shore compass by Würdemann compass.	FIRST SET. Reciprocal bearing from shore compass.	Shore station.	SECOND SET, (ship swinging a little.) Würdemann compass.	SECOND SET, (ship swinging a little.) Ordinary compass.
	°	°		°	°
A	S. 299 E	N. 86 E	2	S. 298¾ E	N. 85½ E.
B	S. 270½ E	N. 61 E	2	S. 271 E	N. 60 E.
C	S. 305 E	N. 32½ E	2	S. 306¼ E	N. 32 E.
D	S. 318¼ E	N. 11 E	3	S. 318¾ E	N. 11 E.
E	S. 347 E	N. 4½ E	3	S. 347¾ E	N. 4 E.
F	S. 233¼ E	S. 36 E	4	S. 232½ E	S. 35 E.
G	S. 303 E	N. 76 E	5	S. 203¾ E	N. 74 E.
H	S. 275¾ E	N. 77 E	6	S. 275¼ E	N. 76 E.
I	S. 300¼ E	N. 65½ E	3	S. 301 E	N. 65 E.

Comparison of above bearings and local deviation.

Station.	Mean bearing of shore compass.	Mean reciprocal true magnetic bearing.	Same + 180°.	Local deviation.
	°	°	°	°
A	S. 299 E	N. 85¾ E	S. 275¼ E	23¾ E. (of N.)
B	S. 270¾ E	N. 60½ E	S. 299½ E	28¾ W.
C	S. 305¾ E	N. 32¼ E	S. 327¾ E	22 W.
D	S. 318½ E	N. 11 E	S. 349 E	30½ W.
E	S. 347½ E	N. 4¼ E	S. 355¾ E	8¼ W.
F	S. 233¾ E	S. 35½ E	S. 215½ E	18¼ E.
G	S. 303½ E	N. 75 E	S. 285 E	18½ E.
H	S. 275½ E	N. 76½ E	S. 283½ E	8 W.
I	S. 300¾ E	N. 65¼ E	S. 294¾ E	6 E.

B.

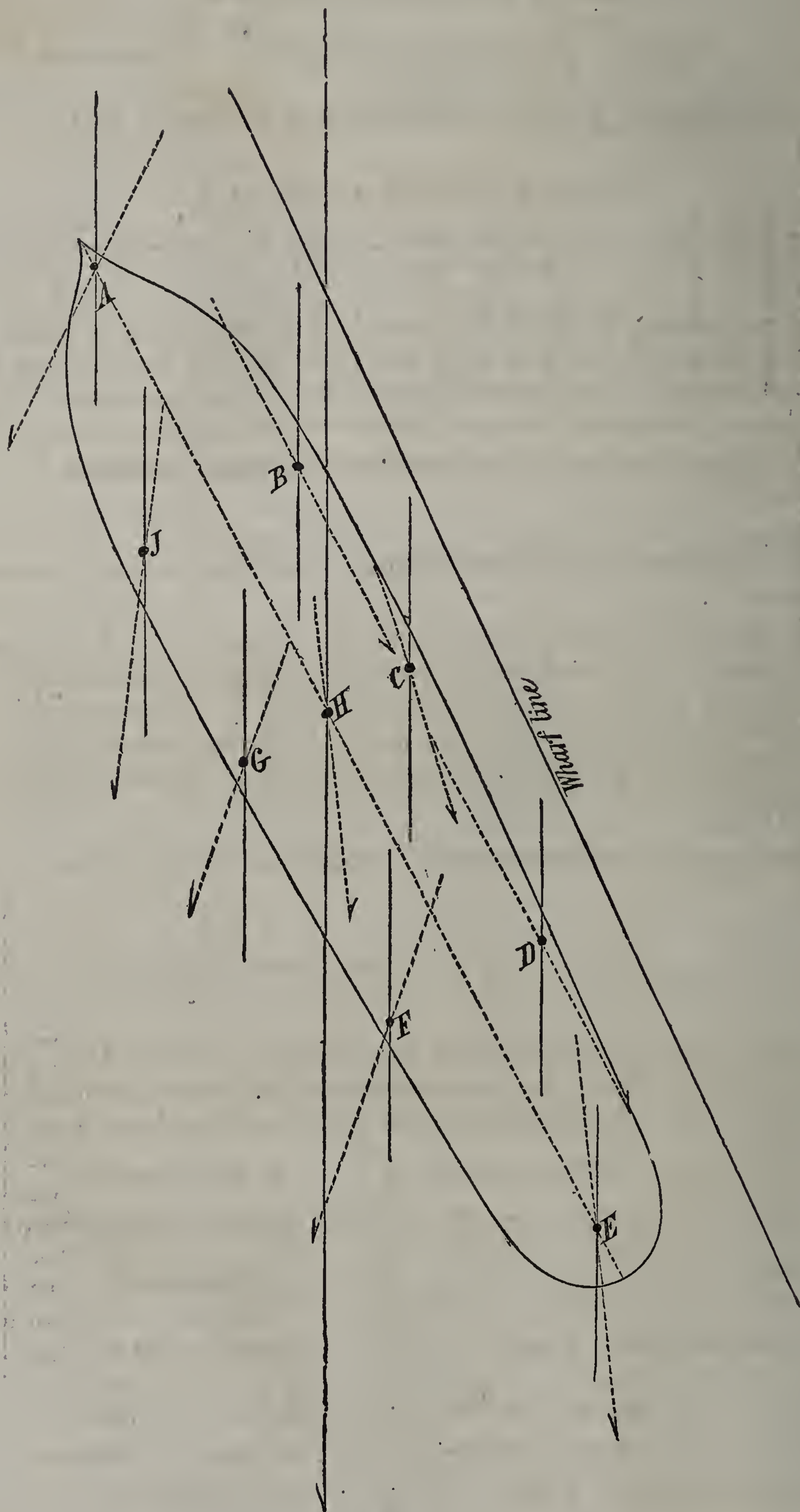


Diagram B exhibits these deviations. The true magnetic meridian is shown by a full line, the apparent one by a dotted line. The E. and W. deflections do not balance, but there is more W. deflection, and somewhere between the axis E A and the positions F, G, I, a line of no deflection can be drawn. How far such a line would remain unchanged when the vessel swings round remains to be seen. It will be seen that the standard compass should be placed as far as practicable vertically over such a line; the diminution of the deflection as we ascend from deck appears at once from the following observations :

Bearing of bow from station E.

On deck	S. 24½° E.	2½ feet above deck	S. 22½° E.	7½ feet above deck	S. 29½° E.
One foot above deck	20½	5 feet above deck	26		

Hence the true bearing S. 28° E. is reached at the height of about 6 feet.

Bearing of stern from station A.

On deck	S. 247½° E.	2½ feet above deck	S. 217° E.	7½ feet above deck	S. 202° E.
1 foot above deck	236	5 feet above deck	211½		

Hence the true bearing S. 208° E. is reached at the height of about 6 feet, as before. Above the small bow turret, 3½ feet from top, the bearing was 211°, and 8 feet above 206°, which gives again nearly 6 feet for no deviation. The action of the ship's iron, however, does not cease at this height, as higher up the deviation points the other way; the experiments might, therefore, be extended to greater elevations.

OBSERVATIONS OF DEFLECTIONS FOR RATIO OF HORIZONTAL INTENSITY.

These experiments were made at the uniform elevation of 1 foot ½ inch above the stations on deck. The scale was placed first at right angles to the true magnetic meridian, next in this meridian, (as prescribed in the paper above alluded to,) in which position the local deviation is shown by the pointing of the needle. One of the deflecting magnets has a slight flaw; it is the one which has been used exclusively.

STATION A.—Scale perp. to mer. Deflecting magnet N. end W.	*E. of mer.*	*W. of mer.*	Scale in mer. Deflecting magnet, N. end E. *S. of station.*	*N. of station.*
At 30 div's	− 6°.0	− 5°.3	+ 7°.0	+ 7°.0
40	+11 .0	+13 .0	+16 .5	+16 .0
50	+17 .0	+14 .8	Needle touches inside of box at zero. At div'n	
Deflected needle at zero. At div'n	35	34.7	27.5	25

While making these experiments the iron steamer Granite Hills came close up to the bow and made fast. In consequence of this, the experiments at station B had to be suspended; the disturbance, on trial, was found too great.

STATION C.—Scale perp. to mer. Deflecting magnet, N. end E.	*W. of m.*	*E. of m.*	In mer. N. end W. *S. of station.*	*N. of station.*
At 30 div's	+ 7.0	+ 3.8	+ 9.0	+11.5
40	+12.5	+13.0	+13.5	+12.8
50 Needle touches.			Touched at zero.	
Deflected needle at zero	27.0 div.	26.5 div.	24.5 div.	23 div.

STATION D.—Scale perp. to mer. N. end E.	*W.*	*E.*	In mer. N. end W. *S.*	*N.*
30 div's	+ 8.0	+ 9.0	+16.0	+15.0
40 Touched.				
At zero	26.0 div.	26.3 div.	19.5 div.	20.5 div.

STATION E.—Scale perp to mer. N. end E.	*W.*	*E.*	In mer. N. end W. *S.*	*N.*
30	− 6.5	− 5.5	+ 1.5	+ 1.0
40	+ 2.5	+ 2.5	+ 5.0	+ 5.3
50	+ 5.5	+ 5.0	+ 6.5	+ 6.5
At zero	36.5 div.	35.5 div.	27.5 div.	28.0 div.

STATION F.—Scale perp. to mer. N. end W.	*W.*	*E.*	In mer. N. end E. *S.*	*N.*
30	+ 5.0	+ 3.0	+11.5	+11.5
40	+11.5	+11.8	+12.5	+12.5
50	+14.8	+14.5	+14.0	+14.5
At zero	27 div.	27 div.	22 div.	21.5 div.

STATION G.—Scale perp. to mer. N. end W. | In mer. N. end E.

	W.	*E.*	*S.*	*N.*
30	3.5	2.8	10.8	10.5
40	11.0	11.0	14.0	14.0
50	13.5	13.0	Touched.	
At zero	28 div.	28.5 div.	21.5 div.	21 div.

STATION H.—Scale perp. to mer. N. end E. | In mer. N. end W.

	W.	*E.*	*S.*	*N.*
30	— 6.3	— 8.0	29.0	29.0
40	+ 1.0	+ 2.3	5.8	6.0
50	+ 6.0	+ 5.8	7.0	7.0
At zero	36.5 3 div.	6.5 div.	29.0 div.	29.0 div.

STATION J.—Scale perp. to mer. N. end W. | In mer. N. end E.

	W.	*E.*	*S.*	*N.*
30	— 5.5	— 6.3	+ 0.5	+ 0.0
40	+ 1.0	+ 1.5	+ 3.0	+ 3.0
50	+ 3.8	+ 4.3	+ 4.5	+ 4.0
At zero	36.0 3 div.	7.0 div.	30.5 div.	29.5 div.

K.—Station on shore for comparison. Scale perp. to mer. N. end W. | In mer. N. end W.

	W.	*E.*	*S.*	*N.*
30	15.5	15.0	7.5	7.8
40	6.3	4.0	3.3	3.3
50	3.5	2.5	1.5	1.5

Theoretically the numbers (value of angle of deflection v) for scale perpendicular to the meridian should be nearly double those for scale in meridian, as they are on the shore station. On board, however, this is found not to be the case, owing to local disturbance. The values for the horizontal force X should be nearly the same for any distance r and corresponding value of v. For the shore station we have:

From 30 $r^3tgv = $	7290 from observations.	$2\,r^3tgv = $	7240 from observations in m.
40	7680 perp. to m.		7300
50	6500		6500
Mean	7160	Mean	7010

Mean.......7085

For the comparison of the intensities we have from the relation $\frac{1}{X} = cr^3tgv$, the ratio $\frac{X}{X_1} = \frac{r^3{}_1tgv_1}{r^3tgv}$, by means of which the following relative intensities—that of the shore station being the unit—have been computed. Only those observations were used in which the local deflection was made to disappear.*

Relative horizontal intensity.

Station.	Mag. in prime vert'l.	In mer.	Mean.	Remarks.
A	2.6	2.3	2.4	Disturbed by presence of an iron steamer.
B	....	....	....	Attempted observation, but found deflection too great, from the above cause.
C	1.1	1.5	1.3	
D	1.4	1.3	1.3	
E	0.9	0.9	0.9	
F	0.9	0.9	0.9	
G	1.0	0.9	0.9	
H	0.9	0.9	0.9	
I	0.7	0.7	0.7	

* I would propose to adjust the instrument to the apparent magnetic meridian in future experiments.

The horizontal intensity appears to be slightly greater on the starboard side and slightly less on the port side than the normal value on shore, which is 4.05, when expressed in absolute value, (feet and grains.)

OBSERVATIONS OF DIP BY LLOYD NEEDLES FOR RELATIVE TOTAL INTENSITY.

June 6, 1863.—The record of these experiments is given in the usual form; the reversal of the nedles and of the circle was dispensed with as unnecessarily refined for the present inquiry.

Let ζ = dip by Lloyd needle.
θ = " " " " with weight attached.
δ = true dip.

For each station we find the dip from the expression $\delta = \zeta + \varepsilon$, where $\sin \varepsilon = \rho \frac{\cos \zeta}{\cos \theta} (\zeta - \theta)$; ε might have been taken constant without affecting the last place of decimals in the result. The relative total intensity is found by the ratio—

$$\frac{\varphi}{\varphi_1} = \frac{\cos \theta \sin (\delta_1 - \theta_1)}{\cos \theta_1 \sin (\delta - \theta)},$$ the total force φ at the shore station being the unit.

If we desire to express the relative intensity in absolute measure, multiply the ratio by 13.6. The dip at the shore station is 72° 22′ by two position needles; the corresponding ζ= 73° 02′; hence ε = — 0° 40′ and ρ = — 0.035; also $\delta - \theta$ =105° 35′.

Station.	ζ	ε	δ	θ	Relative total intensity, $\frac{\phi}{\varphi_1}$
	° ′	° ′	° ′	° ′	
A	80 33	—0 22	80 11	—45 19	0.99
B	75 36	—0 32	75 04	—28 27	1.04
C	75 47	—0 35	75 12	—41 00	0.97
D	75 57	—0 35	75 22	—43 25	0.95
E	73 50	—0 37	73 13	—28 52	1.03
F	65 19	—1 06	64 13	—44 43	0.86
G	65 39	—1 00	64 39	—36 40	0.94
H	62 40	—1 58	60 42	—69 54	0.52
I	68 30	—0 51	67 39	—32 47	0.98

On the starboard side the dip of the needle is greater than the normal value; on the port side it is less. The total intensity, with the exception of station H, does not vary much from the normal value. Station H is amidships, close to masses of iron above deck.

With respect to the intensity observations, both for horizontal and vertical component, the results indicate that it would be desirable to multiply the number of stations.

MAGNETIC DIP.

Station, Brooklyn navy yard. Date, June 6, 10 a. m. Dip circle No. 8. Needle No. 1, (position needle.)

POLARITY OF MARKED END A NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
73 30	73 20	72 25	72 30	73 10	73 05	71 55	72 05
35	20	20	25	05	05	55	05
30	20	25	25	10	05	55	05
73 32. 5	73 20	72 22. 5	72 26. 2	73 07. 5	73 05	71 55	72 05
73 26. 2		72 24. 4		73 06. 3		72 00. 0	
72 55. 3				72 33. 1			
72° 44′. 2							

POLARITY OF MARKED END B NORTH.

CIRCLE WEST.				CIRCLE EAST.			
Face west.		Face east.		Face west.		Face east.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 15	72 10	71 25	71 35	72 40	72 30	72 10	72 05
15	10	35	45	35	25	10	05
15	10	30	40	40	30	10	05
72 15	72 10	71 31. 3	71 41. 3	72 37. 5	72 27. 5	72 10	72 05
72 12. 5		71 36. 3		72 32. 5		72 07. 5	
71 54. 4				72 20. 0			
72° 07′. 2							

Resulting dip .... 72° 25′. 8

Observer, R. E. Halter. Circle reads 85°.

Station, Brooklyn navy yard. Date, June 6, 10.40 a. m. Dip circle No. 8. Needle No. 2, (position.)

POLARITY OF MARKED END A NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 20	72 15	72 10	72 05	72 05	72 10	72 10	72 15
15	10	10	05	05	05	10	15
20	15	10	05	00	05	10	15
.72 17.5	72 12.5	72 10	72 05	72 03.7	72 06.3	72 10	72 15
72 15.0		72 07.5		72 05.0		72 12.5	
72 11.3				72 08.7			
72° 10′.0							

POLARITY OF MARKED END B NORTH.

CIRCBE WEST.				CIRCLE EAST.			
Face west.		Face east.		Face west.		Face east.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 20	72 15	71 55	72 00	72 50	72 45	72 40	72 35
20	15	55	00	50	45	45	40
20	15	55	00	45	45	45	40
72 20	72 15	71 55	72 00	72 48.7	72 45	72 43.7	72 38.7
72 17.5		71 57.0		72 46.8		72 41.2	
72 07.5				72 44.0			
72° 25′.8							
Resulting dip.................................. 72° 17′.9							

LLOYD NEEDLES.

Magnetic Dip.

Station, Brooklyn navy yard. Date June 6, a. m. Dip circle No. 8. Needle No. 1, (L.) Without weight.

POLARITY OF MARKED END A NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 35	72 25	72 40	72 35	72 00	71 55	72 00	72 05
30	25	35	30	00	55	71 55	05
30	25	35	30	00	55	55	00
72 31.2	72 25	72 36.2	72 31.2	72 00	71 55	71 56.2	72 03.8
72 28.1		72 33.7		71 57.5		72 00.0	
72 30.9				71 58.7			
72° 14′.8							

Magnetic Dip.

Station, Brooklyn navy yard. Date, June 6. Dip circle No. 8. Needle No. 2, (L.) Without weight.

POLARITY OF MARKED END A NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 50	72 40	72 35	72 40	72 55	72 50	71 50	71 55
45	40	35	40	50	50	50	55
45	40	40	40	50	45	50	55
72 46.2	72 40	72 36.2	72 40	72 51.2	72 48.8	71 50	71 55
72 43.1		72 38.1		72 50.0		71 52.5	
72 40.6				72 51.2			
72° 45′.9							

For relative intensity. Pin put in the inner hole B end.	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	73 24	73 20 (S.)
Weight in inner hole	— 33 15	— 33 11
Weight in outer hole	— 52 38	— 52 30

ON BOARD VESSEL.

MAGNETIC DIP.

Station A. Date, June 6. Dip circle No. 8. Needle No. 2, (Lloyd.) Uniform height of axle of needle above deck, 14 inches.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	80 38	80 29
Weight in inner hole	— 45 18	— 45 21

Station B.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Weight in inner hole	— 28 27	— 28 28
Without weight	75 40	75 32

Station C.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	75 52	75 42
Weight in inner hole	— 41 00	— 41 00

Station D.

	CIRCLE EAST	
	Face east.	
	S.	N.
	° ′	° ′
Weight in inner hole	— 43 27	— 43 24
Without weight	76 05	75 50

Station E.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	73 55	73 45
Weight in inner hole	— 28 52	— 28 53

Station F.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Weight in inner hole	— 44 45	— 44 42
Without weight	65 18	65 20

Station G.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	65 43	65 35
Weight in inner hole	— 36 28	— 36 32

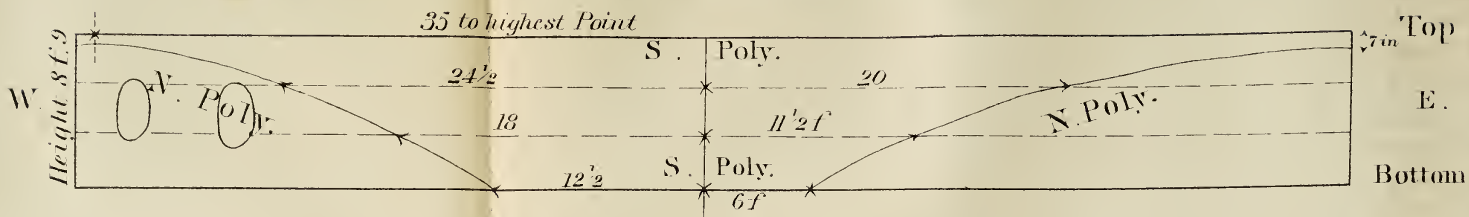
Station H.—Midships.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Weight in inner hole	— 69 57	— 69 50
Without weight	62 40	62 40

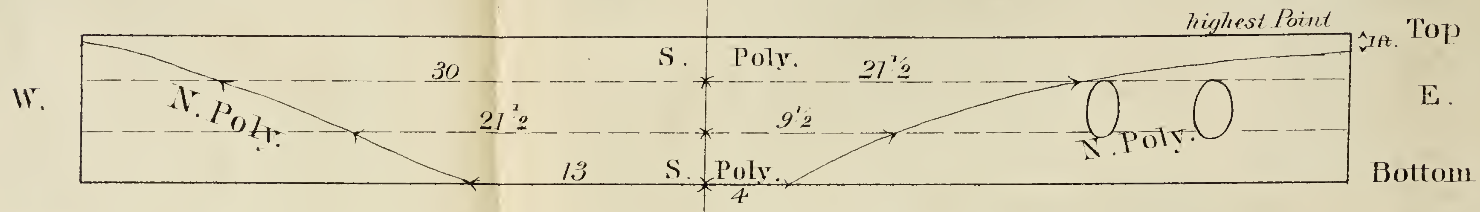
Station I.

	CIRCLE EAST.	
	Face east.	
	S.	N.
	° ′	° ′
Without weight	68 35	68 25
Weight in inner hole	— 32 47	— 32 47

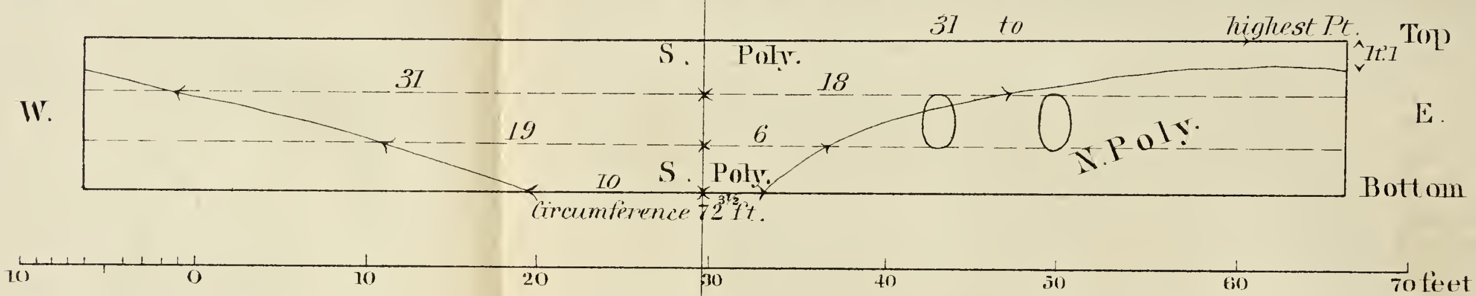
OUTER SURFACE OF BOW TURRET.



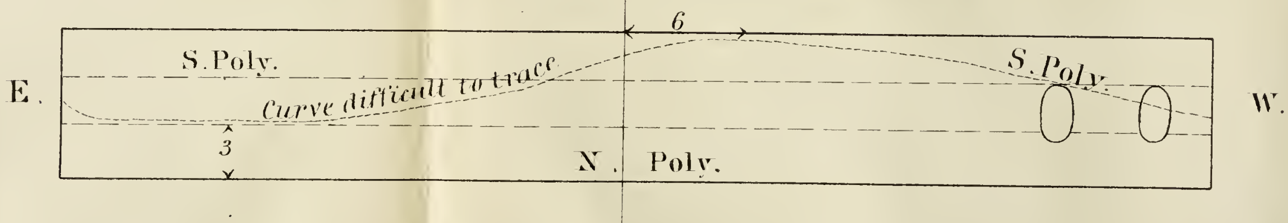
OUTER SURFACE OF MIDDLE TURRET.



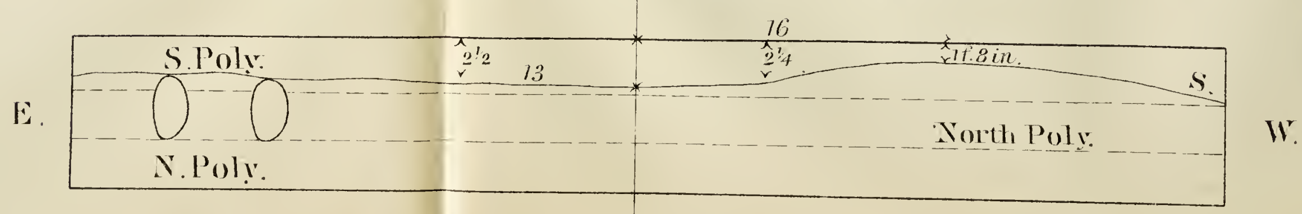
OUTER SURFACE OF STERN TURRET.



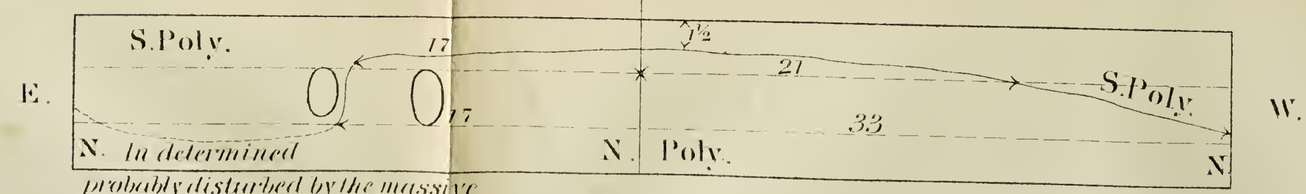
INNER SURFACE OF BOW TURRET.



INNER SURFACE OF MIDDLE TURRET.



INNER SURFACE OF STERN TURRET.



probably disturbed by the massive bar shutters of the port holes.

Lith. of Bowen & Co. Philada.

Top

E.

Bottom

Top

E.

Bottom

Top

E.

Bottom

70 feet

EXAMINATION OF THE POLARITY OF THE TURRETS.

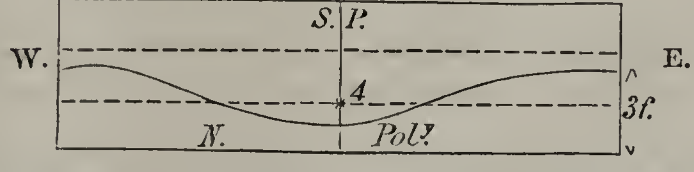
To ascertain the polar distribution of the magnetism of the turrets, I supposed them intersected by four horizontal planes, one on deck, one on top, and two equidistant intermediate ones. The polarity round the circumference of each section was examined inside and outside by a small pocket compass. To obtain a starting line for the horizontal measures, a vertical plane was supposed to pass through the longitudinal axis of the vessel, and by its intersection of that side of the turrets *facing the bow*, furnished the desired line. It is the central vertical line in the diagram. The surface of each turret was then conceived developed on the tangent vertical plane passing through this line and at right angles to the ship's axis. Wherever the polarity was found to change, the distance from the central line was measured, and finally a curve of no polarity (or neutral line) was traced out, as shown in the diagrams. All measures are expressed in feet. The three diagrams are so placed that the eye can easily trace the correspondence in the position of the neutral lines; they refer to the position of the port-holes on June 6. The turrets are 11 inches thick. [See diagram.]

As a general rule, inside the turrets the needle is very sluggish, and in some localities, especially in the vicinity of the shutters, the polarity is difficult to trace out. The distribution within the turrets may be conceived by imagining the curve of no polarity of the outer surface gradually raised near the middle as we proceed inside in the direction of the centre. The bottom part, which has on the outer surface a small sector of about one-fourth of its circumference of S. polarity, will, in the next inner layer, give way, and show N. polarity. On the top outside, as well as inside, we observe S. polarity. The middle of the S. polarity sector lies in an azimuth of 18° W. of the axis of the vessel; that is, it approached the magnetic meridian to with 10°, and will probably coincide with it, if the vessel remains long enough in the present position. A plane intersecting the cylindrical turret through the curve of no polarity, as near as practicable, (the curve being incomplete at the sector part.) makes an angle of about 23° with the horizon, and its complement, or 67°, approaches near enough to the dip, 72½°, to render it probable that the curve will also change with a change in the dip. The distribution of the polarity inside the port-holes is difficult to examine, owing to the effect of the heavy bar shutters. It seems, however, that inside the hole the needle points N. and S., and is very sluggish.

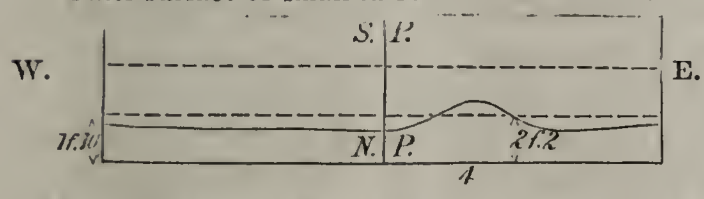
The polarity of the outside of the small top turrets is S., as shown in the diagram, and there is (comparatively little) north polarity all round the bottom part.

Height of turrets, 5 feet 10 inches; circumference, 23 feet; thickness, 8 inches.

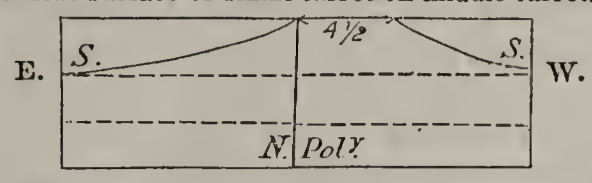
Outer surface of small turret on forward turret.



Outer surface of small turret on middle turret.



Inside surface of small turret on middle turret.



No full examination of the inside of the small turret could be made on account of fresh paint.

I remain, sir, very respectfully, yours, C. A. SCHOTT.

Professor A. D. Bache,

Superintendent United States Coast Survey,

Chairman Compass Committee.

APPENDIX No. 5.

Report of the second (additional) magnetic survey of the iron-clad steamer Roanoke, at the Brooklyn navy yard, June 24–30, 1863, *by C. A. Schott.*

COAST SURVEY OFFICE,
August 4, 1863.

DEAR SIR: In conformity with your instructions of June 20, I visited the steamer Roanoke a second time for additional observations, which, together with their results, are herewith respectfully submitted.

1. COMPARISON OF COMPASSES.

June 24.—The vessel was found in the same position as before, heading (magnetic) S. 28½° E.

Mr. Ritchie's fluid compass above forward turret read S.SE. ¼ S., or S. 19½° E., error ¾ point; on the 27th it read S.SE., or S. 22½° E., error a little over ½ point. The reflector compass above middle turret (Ericsson's, I believe) showed SE. by S. ¼ S., or S. 30¾° E., error less than ¼ point; this compass indicated the same June 27. A tell-tale compass, put up by myself in the captain's cabin, showed (June 27) S.SE. ⅛ E., or S. 24° E., error about ⅛ point. This compass was placed by means of the direction of the deck beams, irrespective of the error it indicated with the heading of the vessel, S. 28½° E., as otherwise the error on another course might be unnecessarily great.

June 29.—Late in the evening the vessel was hauled out in the stream by three steam-tugs.

June 30, 9 *a. m.*—Heading N. 32° W., (nearly the reverse of the previous heading.) Examined compasses again, Ritchie's compass NW. ¼ W., or N. 48° W., error 1⅓ point, (now in opposite direction;) the reflector compass on middle turret had stuck fast, and, not liking to touch it, no further notice was taken of this compass. Tell-tale compass in cabin, NW. by N. ¼ N., or N. 31° W. which is the correct heading. From the above we infer that Ritchie's compass is yet within the range of local disturbance, and would require a mechanical or tabular correction; the latter being the only one practically safe. No opportunity was afforded to test the compasses in any other direction of the vessel. Mr. Frye has not put up any compass. A good locality for placing another compass is in the wardroom under the mess table. In vessels with a wooden hull, (iron-plated,) compasses can safely be placed below deck. Special observations (in appendix A) show no marked deviation between the floor and ceiling of the cabin, (in a vertical plane passing through the longitudinal axis of the vessel.)

1 *(bis.)* ADDITIONAL OBSERVATIONS FOR EFFECT OF ELEVATION ON THE LOCAL DEVIATION AT CERTAIN POSITIONS.—(For record, see appendix B.)

These observations were taken at elevations of 2½, 5½, and 7 feet. At stations I and II, on deck between the turret and side of the vessel, the local deflection increases as we rise above deck, and probably reaches a maximum at a level with the top of the turret. Station VI on the gangway between and even with the top of the larger turrets, shows yet a deviation of ½ point, (at 7 feet elevation.) Station VII is on top of middle turret, on the side of the steering turret; the deviation is considerable, but begins to diminish at a level with the top of small turret. Stations IV and V, nearly over the neutral line, (mentioned in my first report,) show very little deflection at any height examined. At station VIII, in nearly the same line, at the bow, the anchors and smoke-stack appear yet to have some effect.

2. OBSERVATIONS OF DEFLECTIONS AT DECK STATIONS, THE HEADING OF THE VESSEL BEING N. 32° W.

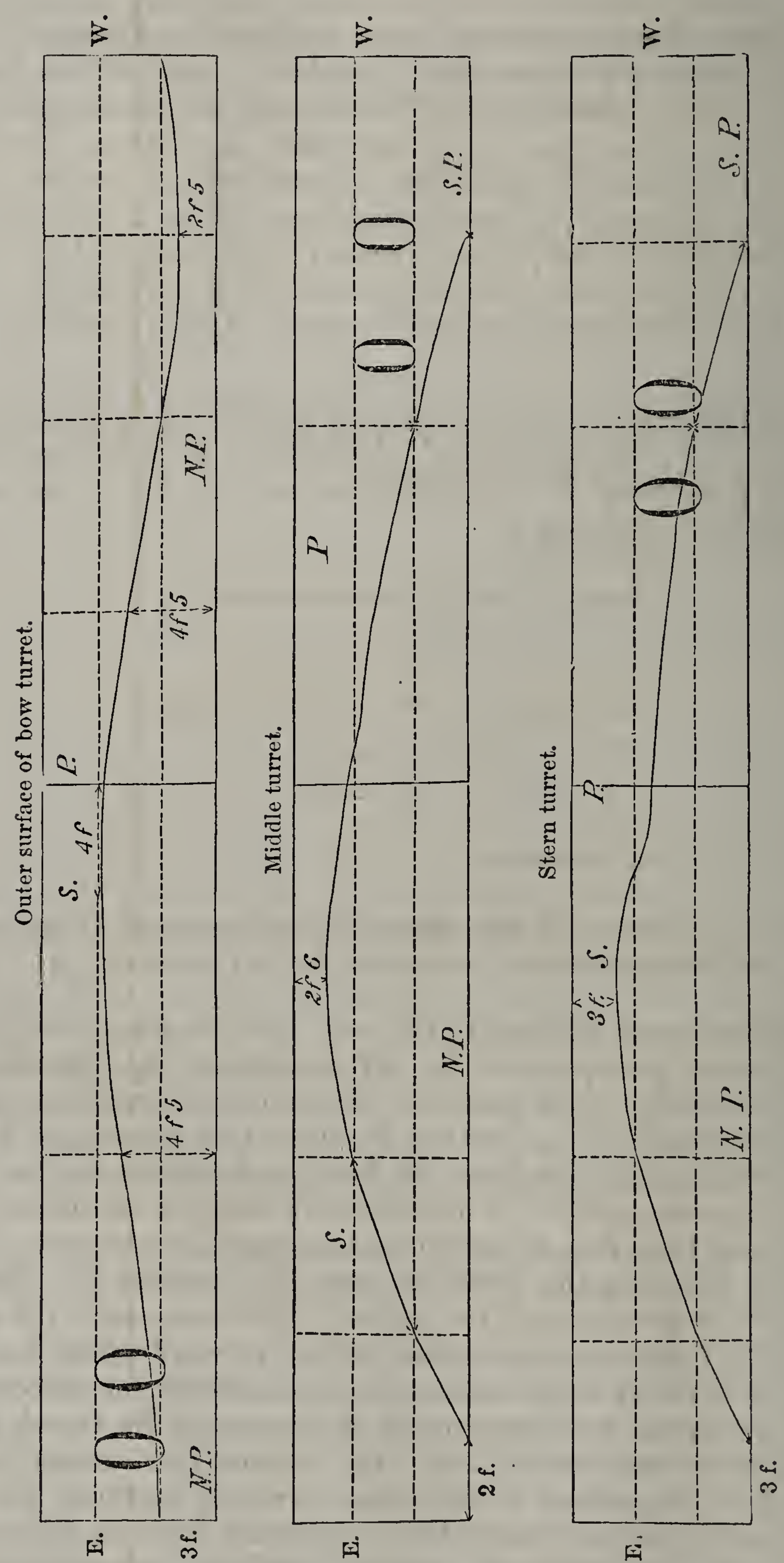
The observations were made on June 30, when the vessel pointed in the direction opposite to that of June 5. Elevation of eye above deck, 5 feet 5.

Former stations.	Bearing of shore station.	Correct and reciprocal bearing.	Local deviation.
	°	°	°
A	321	150.5	9 W.
B	309	145	16 W.
C	295	137	22 W.
D	306	130.7	5 W.
E	311	126.5	5 E.
F	326	130	16 E.
G	318	137.5	1 E.
H	299	137.2	18 W.
I	330	146	4 E.

There still remains more west deflection, as for the ship's heading S. 28° E., and with but one exception, (station A,) the deflections remain on the same side as before. This persistency in west deflection must be due to the action of the permanent magnetism of the ship.

2 (*bis.*) EXAMINATION OF POLARITY OF THE TURRETS, WITH HEADING OF VESSEL N. 32° W. (JUNE 30.)

The diagrams compare directly with those in my first report; the tangent plan is still facing the bow, as before. E. and W. appear, therefore, exchanged on the two sets of diagrams.



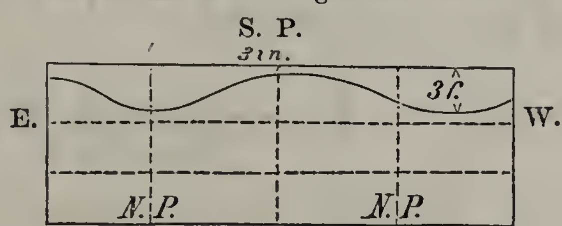
We still find N. polarity prevailing at the bottom and S. polarity at the top of each turret; but the curves have changed when compared with those in the corresponding diagrams in my first report with the heading the opposite of that above. Where we had before the highest ascent of N. polarity there is

now the lowest; in other words, the turrets seem to be wholly under the inductive power of the earth's magnetism. We may conceive the magnetic polarity to remain nearly unchanged while the turret is turned. After an interval of about twelve hours, the exact position of the curves is not re-established. Thus the S. polarity has still to ascend in each turret nearly two feet to reach the former height, (now on the opposite side of the turret,) and at the bow turret the N. polarity is still $2\frac{1}{2}$ feet above deck, at the lowest, although it had turned below and formed the sector (noticed in all the towers before the reversal) in the remaining two turrets. It appears that, under the same conditions, the change in one turret is going on much slower than in another. As the bow turret is now facing N., its greater N. polarity at the bottom may be due in part, also, to the fact that the ship has now more N. polarity near the bottom at the bow end. It also shows that the lapse of half a day is insufficient to restore the distribution of the polarity, although the principal change is most likely effected almost instantly. On this point I shall refer to some experiments made at the Charlestown navy yard. This much seems to be established, that the permanent magnetism plays a very subordinate part in the aspect of the phenomena.

2 (*tris.*) EXAMINATION OF THE POLARITY INSIDE THE FORWARD STEERING TURRET, WHICH WAS NOT ACCESSIBLE AT THE TIME OF MY FIRST VISIT TO THE ROANOKE. (See last page of first report.)

Heading S. 28° E., (June 24.)

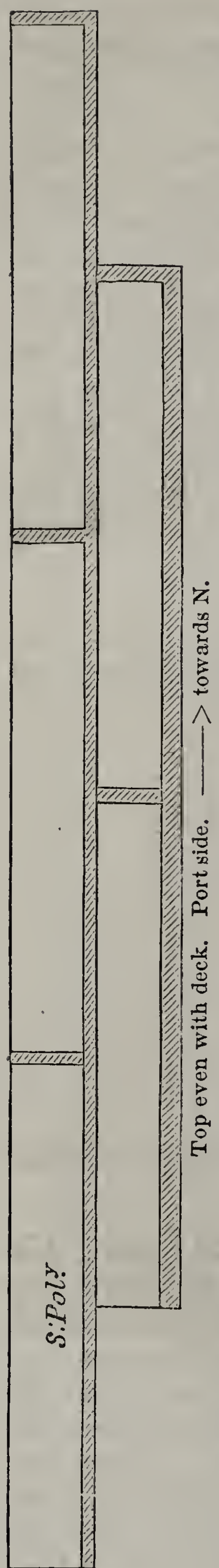
Inside surface of steering turret forward.



See appendix C for the ordinates.

3. OBSERVATIONS AND RESULTS FOR RELATIVE HORIZONTAL INTENSITY IN THE CAPTAIN'S CABIN, TURRETS, &c. (JUNE 25.)

These observations were made with the same instrument as used before. For the detail and record see appendix D. If we express by 100 the horizontal intensity in the Brooklyn navy yard, the horizontal intensity in the captain's cabin will be expressed by 94, (station 1,) three feet above the floor, and by 98, (station 2,) nearly five feet from the floor, and within one foot where the tell-tale compass was suspended. There seems to be ample uninfluenced directive force for it, judging from the action when the vessel was turned. Three feet below the floor of the cabin the force becomes 132, (station 3.) This increase is probably due to the proximity of the rudder. The stations 6, 7, 8 are 2, 4, and 9 feet, respectively, from the outer surface of the forward turret, and *in a level with the line of no polarity on the same;* the force should therefore be less than otherwise, and increase as we approach the side armor of the vessel, near station 8; the resulting forces were 80, 87, and 110. Again, the stations 9, 10, 11 are 2, 4, and 9 feet from the surface of the same turret, $3\frac{3}{4}$ feet from deck, and in a line nearly 90° off from the former line connecting stations 6, 7, 8. In this direction the turret has strong N. polarity, and the respective forces were 253, 195, and 130, diminishing as we recede from the influence of the turret. Inside the forward turret the horizontal force is but 49, (station 4,) and above, inside the little turret, but 43, (station 5.) This strong diminution is due to the neutralizing effect of the opposite side of the turrets, and the



measures hold good for any position inside the turret on the same plane nearly at right angles to the dip. The above stations, 4 and 5, are nearly half way up the height of each turret.

3 (*bis.*) OBSERVATIONS AND RESULTS FOR RELATIVE TOTAL INTENSITY.

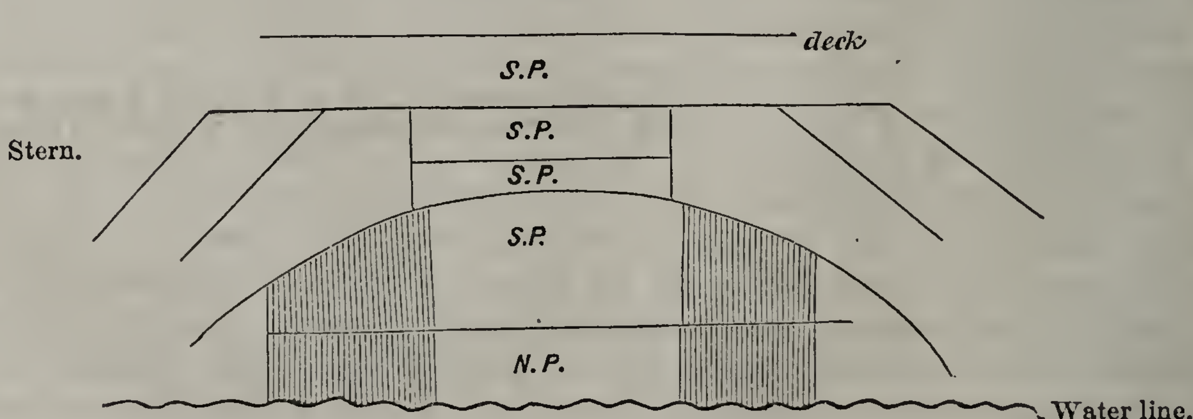
The total force on board at any of the eleven stations occupied is less than the normal value on shore. Calling this latter value 100, one foot above deck over the captain's cabin, the total force is 91; 3 feet from floor in captain's cabin it is 70, and 1 foot from floor 74. The total force within the turrets I had some difficulty in measuring; by cutting the pin weight to its smallest size, (yet convenient for handling,) I found the value 13 in the forward turret and the value 11 in the steering turret above. These are the same positions where the horizontal force was measured.

Inside the turrets (general position as stated) 88 per cent. of the total force is lost or neutralized. At the stations 6, 7, and 8, mentioned above, the total force is 39, 61, and 85, respectively. This increase is in accordance with what has been stated respecting the horizontal force increase. At the stations 9, 10, and 11 the total force is 90, 82, and 81, in correspondence with the decrease noted in the horizontal force, which latter must necessarily be much more affected.

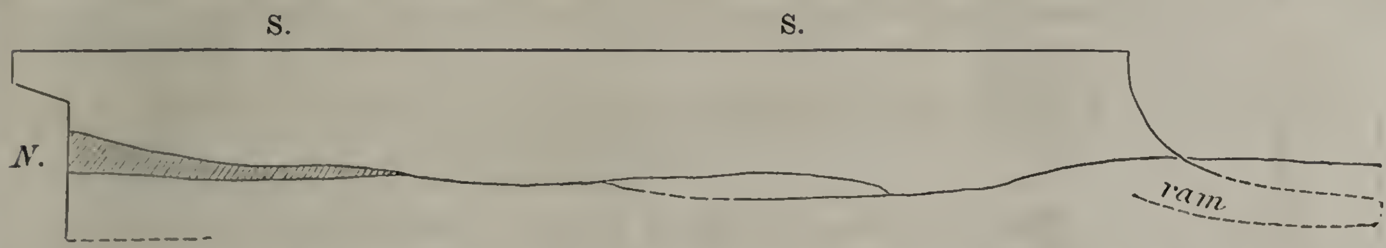
4 EXAMINATION OF MAGNETISM OF ARMOR PLATES, &c. (JUNE 24.)

The armor plates in the sides of the Roanoke are $11\frac{1}{2}$ feet in length, 1 foot 11 inches wide, and $4\frac{1}{2}$ inches thick.

This plating extends to some depth below the water line, draught 22 feet, aft 23 feet. There is S. polarity all round the vessel at the top of the plates, which extends to within three-fourths of an inch to the bottom of each plate. This distance varies from about one-fourth of an inch to two inches. There is also a narrow strip of N. polarity in each end upwards, as indicated by the shaded surface in the diagram. On the starboard side some plates showed all S. polarity; on the port side, turned more towards the magnetic pole, the width of the N. polarity bands increased, and 6 feet 10 inches from deck, nearly at the water line, N. polarity was prevailing altogether. At the stern the general distribution showed S. polarity all round the top to within half the height of the rudder curtain; below this there was N. polarity. (Heading of vessel S. 28° E.)

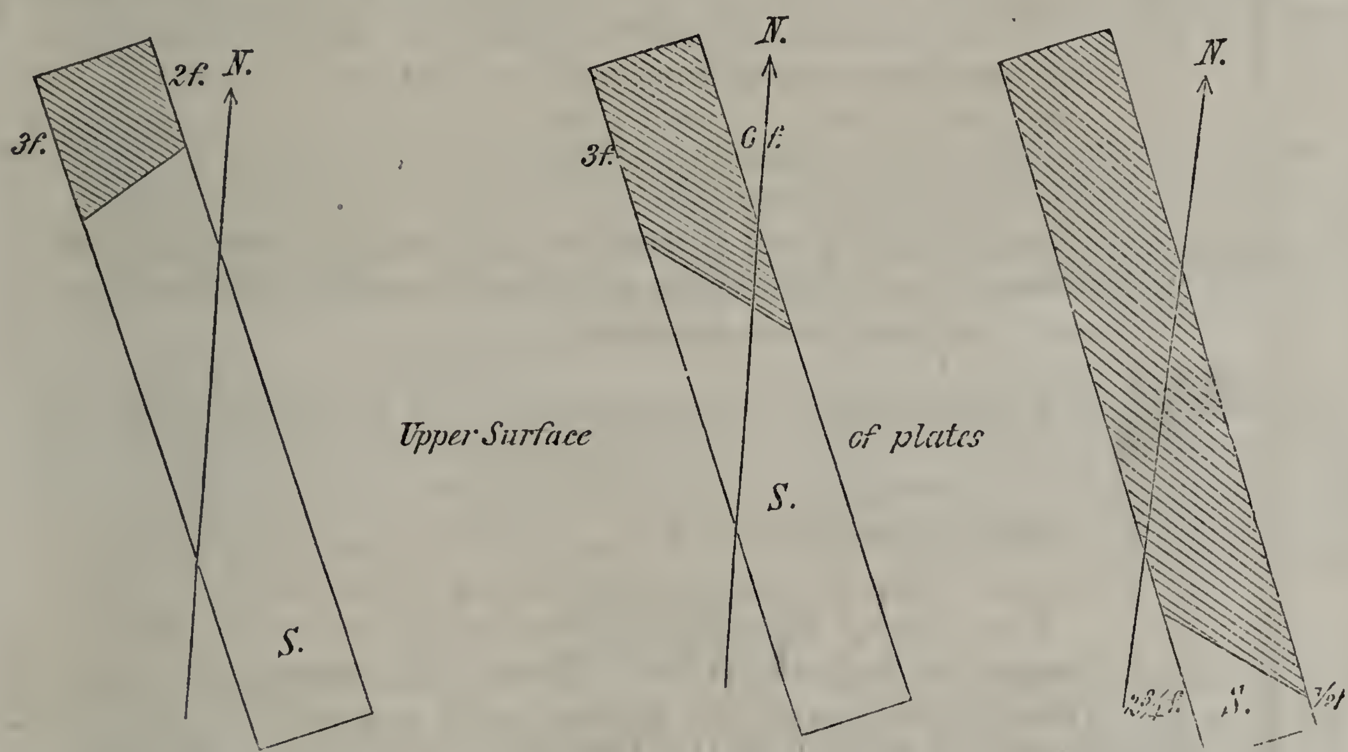


In the side view the part of N. polarity is shaded; the ram, as far as it could be examined, was S. magnetic. It should be stated that the plates do not touch



one another; the seams are filled with some hard substance, and there is, therefore, no direct flow of magnetism through the side armor. On the seam, even on deck, there is generally a narrow strip of N. polarity.

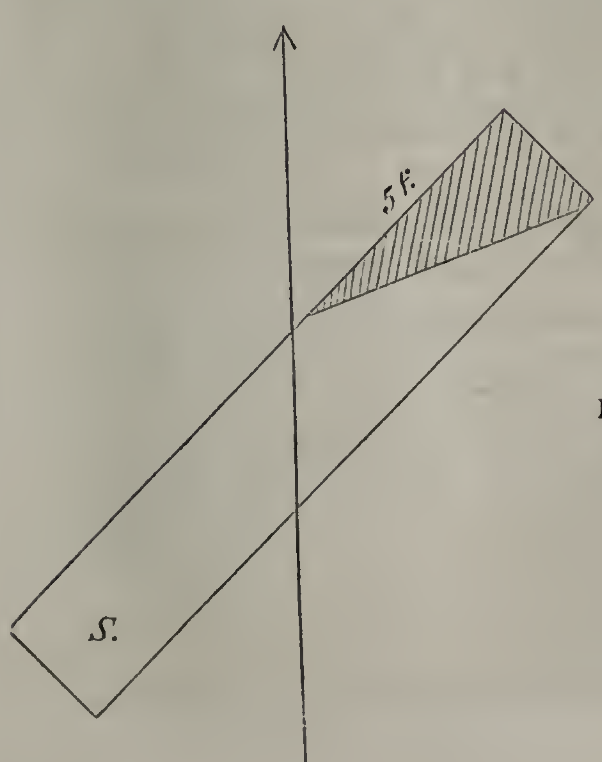
4 (*bis.*) On June 29, examined some iron plates at Webb's ship yard; they are to form the armor of the Dunderberg. These plates were piled up in various directions, but nowhere was there any single plate sufficiently separated from the others so as to admit of independent examination. In the sketches N. polarity is indicated by shading.



Pile of 6 plates lying in direction W.NW. Length, 13 ft. 9; width, 2 ft. 4; thickness, 3½ in. The bottom plate is N., magnetic all round.

Pile of 5 plates lying in same direction. Length, 12 ft. 8; width, 2 ft. 5; thickness, 3 in. The 3 bottom plates are N., magnetic all round.

A single plate, 14 ft. 1 long, 2 ft. 4 wide, and 3½ in. thick. Direction as before. There is N. polarity at the bottom, though very weak at S. end.



Pile of 3 plates, NE., 2½ in. thick, 2 ft. 4 wide, and 14 ft. 3 long. Thewo bottom plates are N., magnetic all round.

Some other experiments on the polarity of plates, bolts, and balls, made at the Charlestown navy yard, will be given in my third report.

Very respectfully, yours,

C. A. SCHOTT.

Professor A. D. BACHE,
Superintendent United States Coast Survey,
Chairman Compass Committee.

APPENDIX A.

Record and reduction.

June 24.—Heading of vessel, from shore station 100 yards off, 27½°, (bearings given by degrees are always understood to count from S. round by E. from 0 to 360°;) 2½ yards nearer, 28½°; 30 yards off, 29½°; mean 28½° Some reverse bearings taken on board a steamer gave unreliable results; no shore locality could be found to the southward of the Roanoke free from objection.

BEARINGS OF BOW, TAKEN ON BOARD.

16½ feet above deck, (above captain's cabin,) 25°; 7 feet above, 27°; 5½ feet above, 21½°; 1¾ foot above, 16°; on deck, 18°; below deck, captain's cabin, tell-tale compass, 24° (on the 27th;) 1¾ foot below ceiling, 31½°; on table in cabin, 4½ feet below ceiling, 30°; 5¼ feet below, 31°; on floor, 7 feet below, 31°.

HEADING OF VESSEL JUNE 30, A. M.

At stern flag-staff 209°; middle of deck, about 15 feet from stern, 210°; above captain's cabin, 225°, (all 15½ feet from deck;) mean 215°, or N. 35° W. Near bow, station A, 33°; at bow, 22°; between A and bow, 32°; mean 29°, or heading N. 29° W.; mean of both, N. 32° W.

APPENDIX B.

June 25.—Reciprocal bearings for local deviations; observations on board by myself, on shore by E. H. Courtenay. Heading of ship 27½°.

Station I. Starboard, between middle turret and side.
" II. Starboard, between after turret and side.
" III. Starboard off rudder.
" IV. Port side, off rudder, on or near neutral line.
" V. Between after turret and rudder, on or near neutral line.
" VI. On gangway, between after and middle turret.
" VII. Top of middle turret, between steering turret and starboard side.
" VIII. Near bow and neutral line.

STATION I.				STATION II.			
Elevat'n above deck.	Bearing of shore stat'n.	Reverse bearing.	True magnetic bearing.	Elevation.	Bearing of shore stat'n.	Reverse bearing.	True magnetic bearing.
Feet.	°	°	°	*Feet.*	°	°	°
At 2½	341¾	156½	337	At 2½	331	172½	352½
5½	357½	157½	....	5½	7	173	....
7	360	156½	....	7	13	172	....

STATION III.				STATION IV.			
2½.........	356¾	180	359	2½.........	351	173½	353
5½.........	1	179¾	....	5½.........	354½	172½	....
7	2½	176	....	7	353½	173	....

STATION V.				STATION VI.			
2½.........	344	170½	350	2½.........	329	161¾	342
5½.........	343¾	167½	....	5½.........	334½	163	....
7	344	171	....	7	336	161½	....

STATION VII.				STATION VIII.			
2½.........	3	155	334	2½.........	286	95¼	276
5½.........	9	153¾	....	5½.........	271½	96	....
7	5½	154	....	7	267½	96½	....

Appendix C.

The ordinates of the curve, separating the N. and S. polarities, count from the top, and the abscissæ from the middle line, from 0 to 360° westward.

Abscissæ.	*Ordinates.*	*Abscissæ.*	*Ordinates.*
0 (middle line.)	3 in.	180 (middle line.)	1 f.
45	6 in.	225	1 f.
90	3 f. 3.	270	2 f.
135	3 f. 2.	315	3 in.

Appendix D.

Record and reduction of the observations for relative horizontal intensity.

June 25.—The distance of the magnet from the centre of scale, if not otherwise stated, is 45 divisions. The magnet was placed successively as follows: Sc. at right angles to magnetic (apparent) meridian; magnet E., N. end E., N. end West; magnet West, N. end W., N. end E., Sc. in magnetic (apparent) meridian; magnet N., N. end E., N. end W.; magnet S., N. end W., N. end E.

STATION 1.—In captain's cabin, 3 ft. 1 from floor.

Distance, 45:	°	°	°	°	°
Scale at r. a......	4½	4¾	5	4½	Mean, 4.7
Distance, 35:					
Scale at r. a......	9¼	10½	10¾	10	10.1
Distance 45:					
in mer (W.=½)	½	1	2	2	(?) 1.4
Distance, 35:					
in mer......	4¾	5	5½	4¾	5.0

STATION 2.—In captain's cabin, 4 ft. 9 from floor, within 1 foot of the position of the tell-tale compass, put up some days after.

Distance, 45:					
Scale at r. a......	3¾	8½	5¾	2	Mean, 5.0
in mer (W.=½)	¾	¾	2	½	(?) 1.0

STATION 3.—In hold, 3 ft. 3 in. below floor of cabin.

Scale at r. a......	3¾	3½	3¼	3½	Mean, 3.5
in mer....	1¼	1½	1¾	1½	1.5

STATION 4.—In forward turret, between smaller gun and side of turret, 3¼ ft. from floor.

Scale at r. a......	10	10	7¾	9¼	Mean, 9.2
in mer.....	6½	3¾	3	4½	4.2

STATION 5.—In steering turret, forward, 3½ ft. above its floor.

Scale at r. a......	9	12½	11¾	10	Mean, 10.8
in mer.....	7½	1	3½	6	4.5

STATION 6.—On deck port side, off forward turret, 2 ft. from turret; height, 4 ft. 2; equal elevation of curve of no polarity.

Scale at r. a......	5½	5¼	5	6	Mean, 5.4

STATION 7.—On deck, as above, 4 ft. from turret.

	°	°	°	°	°
Scale at r. a......	5	5	4½	5¾	Mean, 5.1
in mer.....	2¾	2½	2¾	1¾	2.4

STATION 8.—On deck, as above, 9 ft. from turret.

Scale at r. a......	4	4¼	4½	4¼	Mean, 4.2
in mer.....	2	2	1½	1½	1.8

STATION 9.—On deck, 3¾ ft. from deck, 2 ft. from forward turret; in line at r. a. to former line of stations 6, 7, 8. (See diagrams.)

Scale at r. a......	2¼	1½	1½	2	Mean, 1.8
in mer.....	½	1¼	¾	½	0.8

STATION 10.—On deck, as above, 4 ft. from turret.

Scale at r. a......	2	3	2¼	2	Mean, 2.4
in mer.....	1¼	¼	¾	1¼	1.0

STATION 11.—On deck, as above, 9 ft. from turret.

Scale at r. a......	2½	3½	3¾	3¼	Mean, 3.2
in mer.....	1¾	1¾	1¾	1½	1.7

STATION 12.—On shore, 3 ft. 6 above ground.

Distance, 45:					
Scale at r. a......	4¼	4½	3¾	4¼	Mean, 4.2
in mer (W=¼)	1¾	1	1½	1¼	(?) 1.4
Distance, 35:					
Scale at r. a......	8½	10¼	9¾	9	Mean, 9.4
in mer.....	4¼	6	5¼	4¼	4.9

Station.	r^3tg v.	Relative X.	Station.	r^3tg v.	Relative X.
1	7306	0.94	7	7886	0.87
2	7014	0.98	8	6209	1.10
3	5172	1.32	9	2704	2.53
4	14070	0.49	10	3500	1.95
5	15860	0.43	11	5252	1.30
6	8614	0.80	12	6847	1.00

APPENDIX E.

Record and reduction of observations for relative total intensity.

June 24.—These observations were made with the Lloyd needle No. 1, and position needle No. 1, in position 3½, belonging to dip circle No. 8. The pin weight is the same as that used before.

MAGNETIC DIP.

Station, Brooklyn navy yard. Date, Wednesday, June 24, 1863. Dip circle No. 8. Needle No. 1. Position 3½

POLARITY OF MARKED END N.

CIRCLE EAST.				CIRCLE WEST.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 29	72 44	73 00	73 00	72 22	72 51	72 42	72 53
73 15	73 26	72 38	72 33	53	28	02	18
73 18	73 10	72 38	72 36	18	20	00	48
72 51	72 48	72 48	72 49	54	52	27	30
72 58	73 02	72 47	72 46	72 37	72 38	72 18	72 38
73 00.0		72 46.5		72 37.5		72 28.0	
72 53.2				72 32.7			
72 43.0							

POLARITY OF MARKED END S.

CIRCLE WEST.				CIRCLE EAST.			
Face west.		Face east.		Face west.		Face east.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
72 05	72 01	71 50	72 22	73 08	72 49	72 45	72 41
20	20	72 18	02	72 50	34	09	04
00	39	71 52	21	73 00	48	35	32
42	05	72 06	02	72 51	38	10	09
72 17	72 16	72 01	72 12	72 57	72 42	72 25	72 22
72 16.5		72 06.5		72 49.5		72 23.5	
72 11.5				72 36.5			
72 24.0							

Resulting dip.............................. 72° 33′.5

Observer, C. A. Schott.

	° ′
Circle reads,	51 05
	51 12
	52 28
	50 15
Mean,	51 15

Completed at 4*h*. 35*m*. p. m.

On shore station. Circle E. Face E. Lloyd needle 1:

Dip with pin................	59° 02′	59° 08′	Without pin...............	72° 58′	72° 40′
Mer. 54°................	58 47	59 00		72 32	72 59
Mean................	58° 59′			72° 47′	

One foot above deck, over captain's cabin:

Dip without pin............	68° 22′	68° 28′	With pin..................	47° 35′	47° 45′
Mer. 39°................	66 55	67 05		47 56	47 59
Mean................	67° 42′			47° 49′	

In captain's cabin, 3 feet 1 from floor, station No. 1 of June 25, (hor. inten'y:)

Dip without pin............	67° 30′	68° 45′	With pin..................	35° 30′	35° 44′
	68 40	67 40		37 10	37 12
Mean................	68° 09′			36° 24′	

One foot above floor in captain's cabin:

Dip with pin................	42° 00′		Without pin...............	70° 10′	
	44 50			70 20	
Mean................	43° 25′			70° 15′	

In forward turret, 3½ feet from gun, station No. 4 of June 25:

Dip without pin............	25° 35′	25° 50′	With pin..................	—73° 30′	—73° 50′
Mer. 69°................	40	45		—74 40	—74 50
Mean................	25° 42′			—74° 12′	

In forward steering turret, station No. 5 of June 25, two feet from centre:

Dip with pin................	—83° 30′		Without pin...............	68° 45′	
	—83 15			68 00	
Mean................	—83° 22′			68° 22′	

At station No. 6 of June 25, 2 feet from turret, on level with line of no polarity:

Dip without pin............	60° 28′	60° 12′	With pin..................	—30° 30′	—30° 28′
Mer. 32°................	59 40	59 53		—30 05	—30 10
Mean................	60° 03′			—30° 18′	

At station No. 7 of June 25, 4 feet from turret:

Dip with pin................	22° 05′	21° 40′	Without pin...............	66° 05′	66° 08′
Mer. 30°................	21 30	22 05		65 48	65 55
Mean................	21° 50′			65° 59′	

At station No. 8 of June 25, 9 feet from turret:

Dip without pin	70° 00′	70° 03′	With pin	49° 10′	49° 12′
Mer. 49°	69 28	69 38		48 55	49 05
Mean	69° 47′			49° 05′	

At station No. 9 of June 25, 2 feet from turret:

Dip with pin	+ 1° 10′	− 0° 50′	Without pin	31° 12′	30° 05′
Mer. 78°	− 0 58	+ 0 45		30 40	30 30
Mean	+ 0° 02′			30° 37′	

At station No. 10 of June 25, 9 feet from turret:

Dip without pin	53° 10′	53° 05′	With pin	21° 12′	21° 18′
Mer. 58°	52 22	52 31		21 20	21 24
Mean	52° 47′			21° 19′	

At station No. 11 of June 25, 9 feet from turret:

Dip with pin	+39° 20′	39° 55′	Without pin	65° 32′	65° 38′
Mer. 47°	39 40	39 25		64 50	64 58
Mean	39° 35′			65° 14′	

$\varepsilon = \delta - \varsigma = - 13°.5$ has been taken as constant.

$\frac{\varphi}{\varphi,} = \frac{\cos \theta \sin (\delta, - \theta,)}{\cos \theta, \sin (\delta - \theta)}$, the total force φ at the shore station will be taken as the unit.

The pin weight now used is only about half the size of that used June 6, in order to permit the measures the total intensity within the turrets. We have:

$$\varphi, = [9.6587.6] \frac{\cos \theta,}{\sin (\delta, - \theta,)}$$

Station.		δ	θ	$\delta - \theta$	$\frac{\phi_1}{}$
	° ′	° ′	° ′	° ′	
On shore	72 47	72 34	58 59	13 35	1.00
Above captain's cabin	67 42	67 29	47 49	19 40	0.91
In captain's cabin	68 09	67 56	36 24	31 32	0.70
Floor of captain's cabin	70 15	70 02	43 25	26 37	0.74
Forward turret	25 42	25 29	−74 12	99 41	0.13
Forward steering turret	68 22	68 09	−83 22	151 31	0.11
2 ft. from forward turret, towards port side	60 03	59 50	−30 18	90 08	0.39
4 do. do. towards port side	65 59	65 46	21 50	43 56	0.61
9 do. do. towards port side	69 47	69 34	49 05	20 29	0.85
2 do. do. towards stern	30 37	30 24	0 02	30 22	0.90
4 do. do. towards stern	52 47	52 34	21 19	31 15	0.82
9 do. do. towards stern	65 14	65 01	39 35	25 26	0.81

APPENDIX No. 6.

THIRD REPORT ON MAGNETISM OF IRON-CLAD VESSELS.

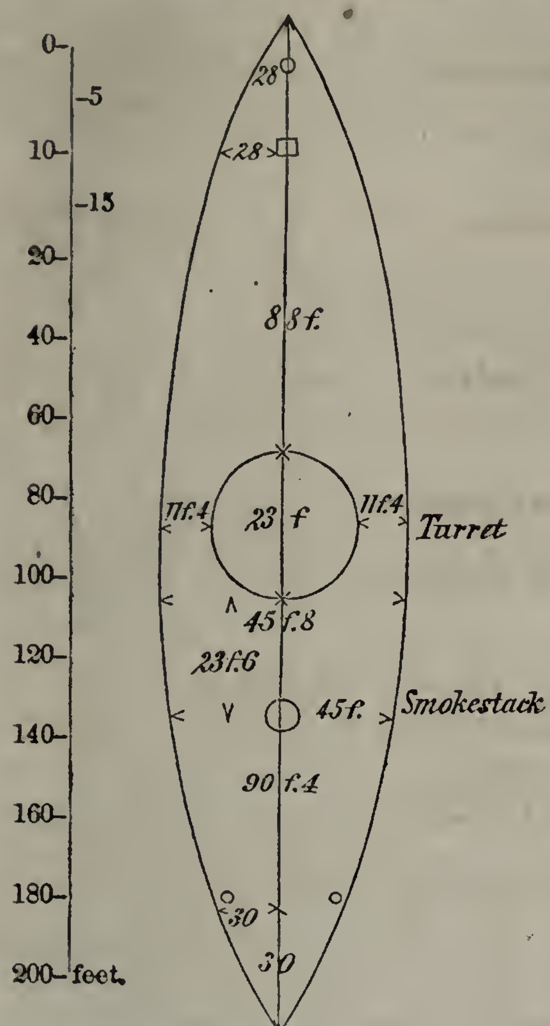
Magnetic survey of the Ericsson battery Passaic at the Brooklyn navy yard, June 25, 26, and 27, 1863, with an appendix on some experiments at the Charlestown navy yard July 3, by C. A. Schott, assistant United States Coast Survey.

The Passaic is an iron vessel, with one turret nearly amidships. On the top of it there is a small steering turret. Total length nearly 200 feet; diameter of turret 22 feet 11; height 8 feet 9; thickness 11 inches; thickness of sides of vessel 4 feet 10; draught of water about 9 feet.

The methods and instruments employed in the survey of the Passaic are precisely the same as used in the survey of the Roanoke, and no further expla-

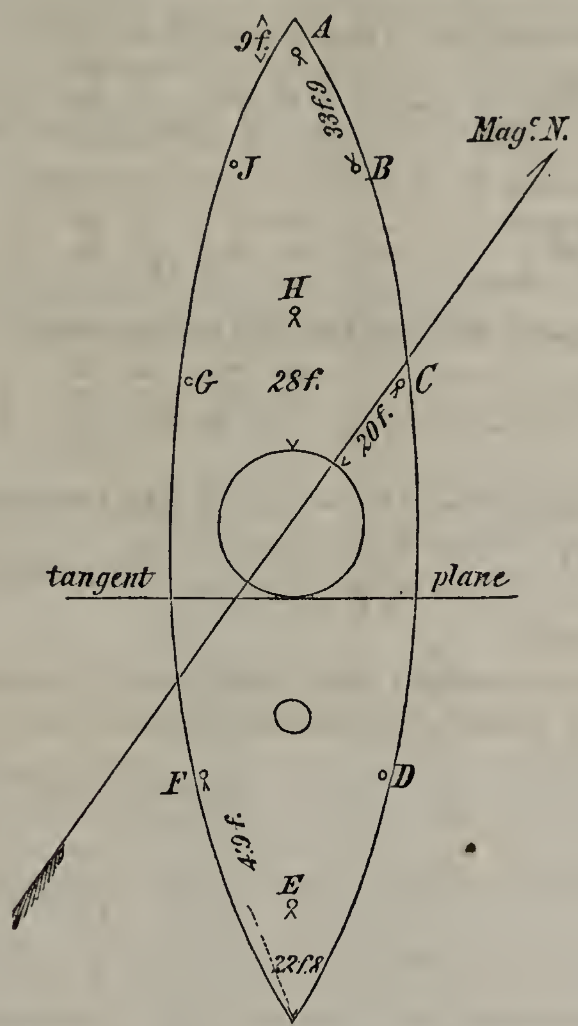
nation, in this respect, is therefore required. As in the second report on the latter vessel, the results and the record and computation are kept separate.

Deck plan of the Passaic.



Stern.

Position of magnetic stations.

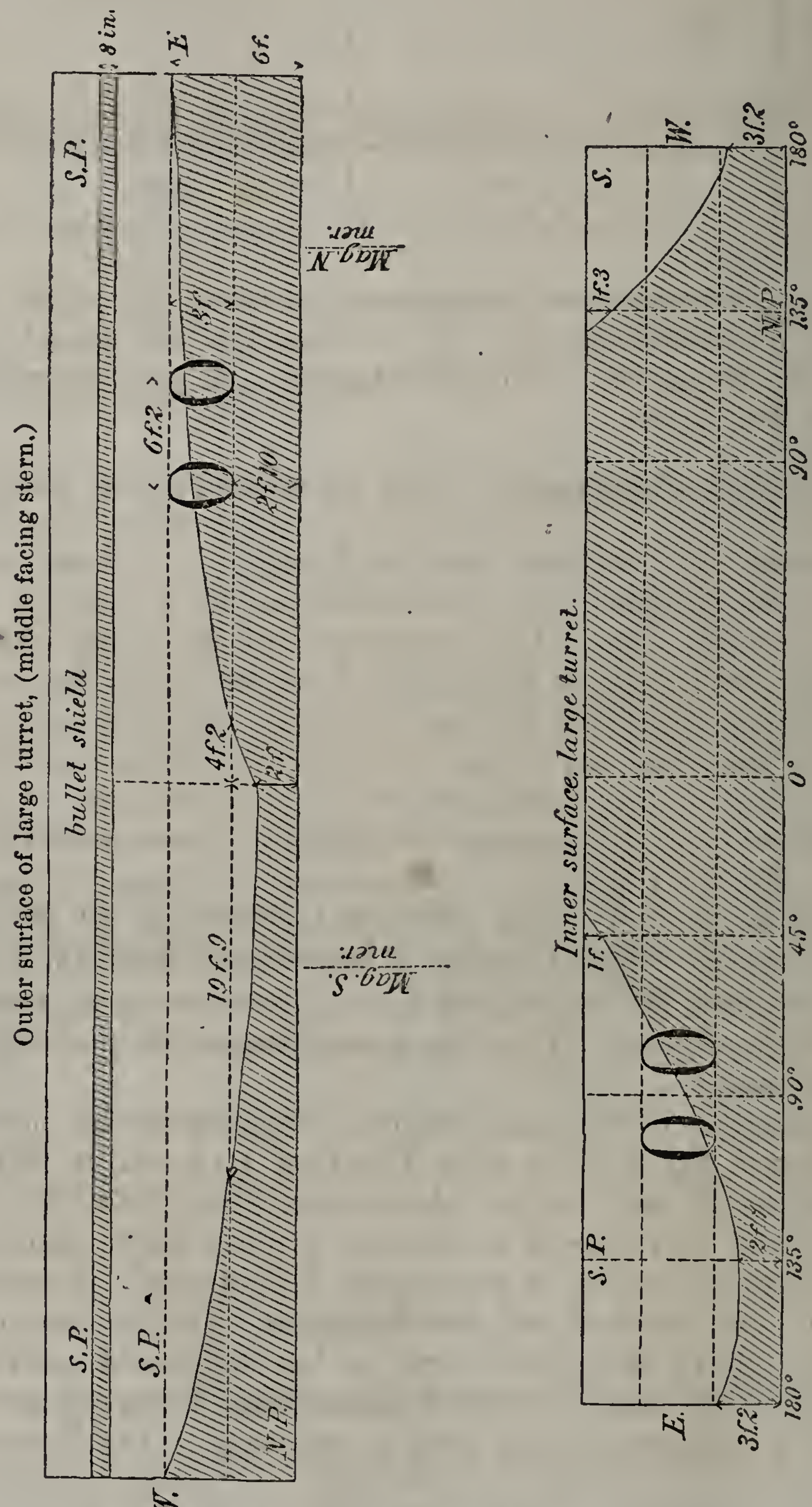


Distance of B, C, D, F, G, I, from side of vessel, 4 ft.

During my stay in New York the Passaic remained in the same general direction; the turret also remained stationary, workmen being busily engaged upon it and the small steering turret on top.

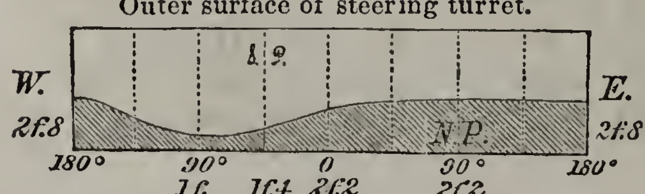
Polarity of turrets and plates. (*June* 25.)

Heading of vessel NW. by N.; tangent plan of development as shown on preceding sketch. Dimensions of turret: Height 8 feet 9; circumference 72 feet; thickness 11 inches; shield on top 2 feet 4 high and one-fourth inch thick. Dimensions of steering turret: Height 5 feet 10; circumference 25 feet; thickness 11 inches; N. polarity indicated by shading.

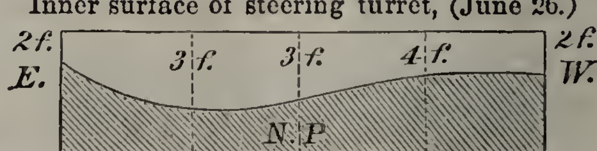


At the outer surface the N. polarity curve descends lowest in the southern half of the magnetic meridian and highest in the northern half The distribution of polarity is practically the same as on the towers of the Roanoke. As the Passaic was but a short time in the yard, the lowest and highest points of the curve are probably not yet attained.

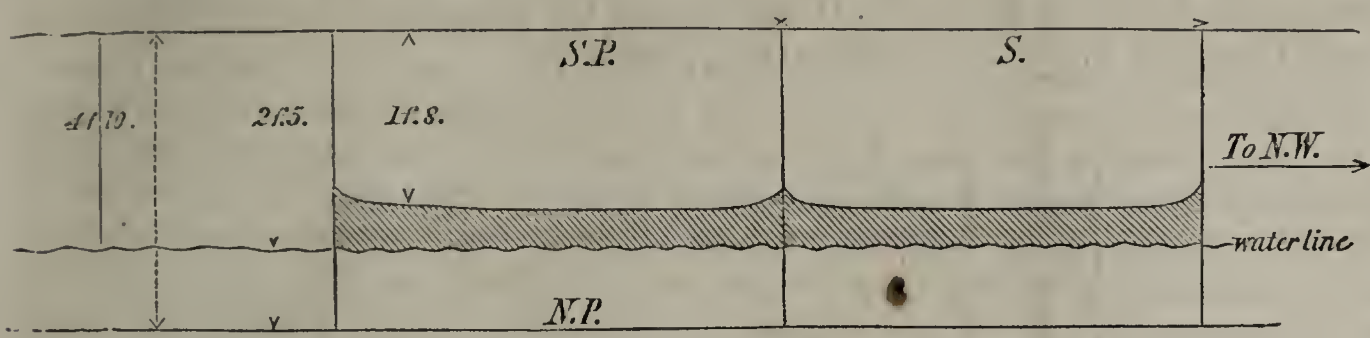
Outer surface of steering turret.



Inner surface of steering turret, (June 26.)



We notice again the greater surface of N. polarity *inside* the turrets compared with the less amount outside. There is S. polarity around the top of the vessel along its sides. The plates are nearly five feet long, overlapping each other, and forming a total thickness of 4 feet 10. There is but one width reaching from below the water-line.

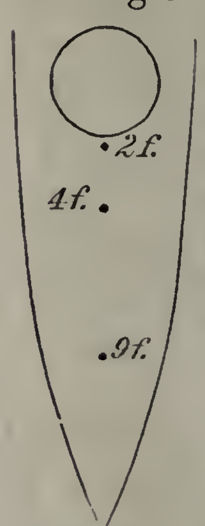


There is no open seam between the plates, yet there is a slight turn up of N. polarity, near the northernmost edge, the rudiment of the broad band as found on the plates of the Roanoke. Along the top of each plate there is S. polarity, width from 1 foot 8 to 2 feet.

Measures of horizontal force above and below deck.

These observations were made as usual, and are given in detail in appendix A. At each of the deck stations, A to I, observations were made at elevations of 1 foot and of 3 feet 7 inches. The starboard and stern stations B, C, D, E, give the relative horizontal force 0.79, 0.72, 0.56, and 0.58, that on shore being 1.00; the port stations and bow stations F, G, I, and A, give 1.08, 1.07, 0.93, and 1.15; mean of the first set (of small values) 0.66, and of the second set 1.06. The station H is intermediate, (0.80.) The effect of an elevation of 2 feet 7 is, upon the average, to increase the horizontal force from 0.85 to 0.99; in other words, the effect of the deck is to diminish the force. At an elevation of 3 feet above deck the average value 1.00 will be reached, (if the same ratio of increase holds.) In the captain's cabin, 3 feet 7 from floor, the force is 0.73, 1 foot below this station 0.96, and on the floor 2.39, showing an increase of force in either direction from deck. The last named station is probably affected by some local disturbance.

Along the central line of the vessel in the direction of the bow, 2 feet from the turret, the force is 1.79, 4 feet off 1.19, and 9 feet off, 1.10, the elevation of each station above deck being 3 feet 7. The effect of the turret, therefore, is to increase rapidly the horizontal force as we approach it, where it has strong N. polarity. Precisely the same result was reached on the Roanoke. Inside the turret (3 feet 7 inches above floor) the force is but 0.32, and inside the steering turret, in its axis, (3 feet 7 inches from floor,) it is 0.35. This is even a greater decrease than in the case of the Roanoke.



Bow.

MEASURES OF TOTAL FORCE.

The relative total force was determined by means of Lloyd needle No. 1, circle and face east. For record and reduction see Appendix B. The same small pin weight was employed as on the Roanoke June 24. Of the deck stations 7 out of 9 give smaller force than on shore, viz: (10 inches above deck.) Total force on shore equal to 1.00.

A	B	C	D	E	F	G	H	I
.89	1.01	.86	.98	1.13	.92	.74	.92	.99

At the same stations, 4 feet 10 above deck, we have 1.10, .94, .90, .99, 1.12,

.94, .73, .84, .86, showing but little change in the average. Mean of force 10 inches above deck 0.94, and 4 feet 10 from deck 0.93 Examining the column containing θ, (in the appendix,) we find the dip on the starboard side is considerably greater than on the port side; the total force also is greater on the starboard side. Inside the steering turret the total force is but 0.52, and inside the large turret but 0.13, precisely the same as found in the forward turret of the Roanoke. In the captain's cabin the total force varies but little at heights between 11 inches and 5 feet 6 inches above floor, viz: 0.34, 0.31, 0.28, 0.31, mean 0.31, the smallness of which value is due to the fact that the hull of the Passaic is of iron. Neither the horizontal nor the total force in the cabin appears favorable for the working of a compass placed in it. A trial may be made, but I doubt its success as a steering compass while at sea. At the stations above deck, 2, 4, and 9 feet off the turret, we have, respectively, 0.67, 0.74, and 0.84, an increase of force as we recede from the N. polarity of the side of the turret. This increase may be due to the fact that the position of the line of no polarity is but one foot above the height of the stations.

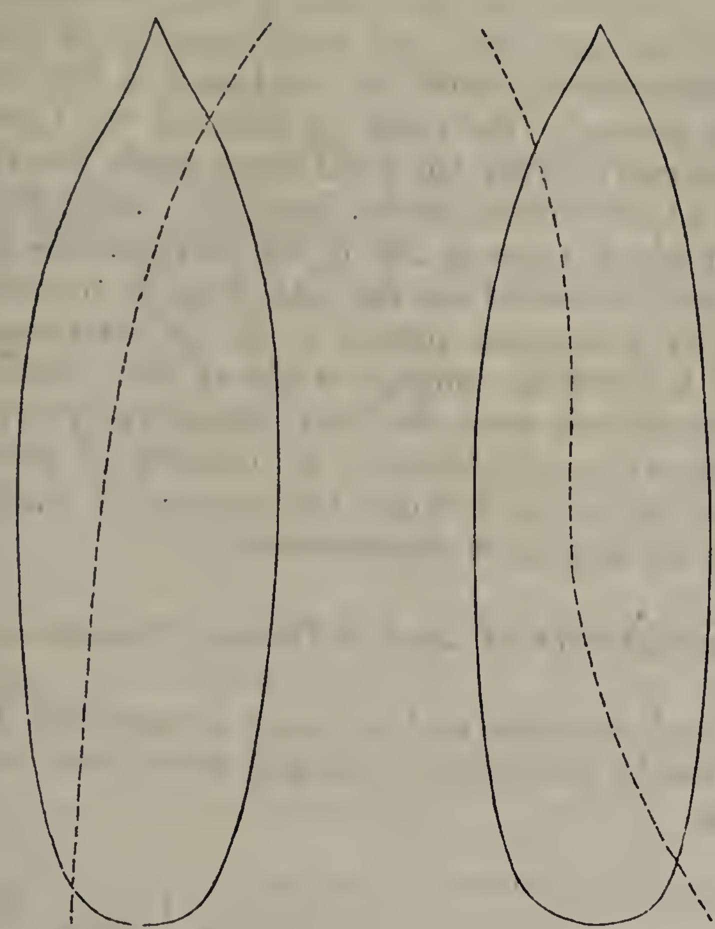
Examination of local deflection of compass.

The observations, both on shore and on board, are given in Appendix C. The compasses had previously been compared, and were found to agree within the limits of observation.

Station.	Elevation above deck.	Bearing of shore compass.	Correct reciprocal bearing.	Local deviation. (from N.)
	Feet.	°	°	°
A	2.6	267	270½	3½ W.
	5.5	267		3½ W.
	8.5	269½	266	3½ E.
B	2.6	250	269	19 W.
	5.5	242½		26½ W.
	7.5	244		25 W.
C	2.6	231	266¼	35¼ W.
	5.5	241		25¼ W.
	7.5	244		22¼ W.
D	2.6	244	259¼	15¼ W.
	5.5	235		24¼ W.
	8.5	231		28¼ W.
E	2.6	238	256½	18½ W.
	5.5	232		24½ W.
	6.5	238		18½ W.
F	2.6	254½	255¾	1¼ W.
	5.5	255½		¼ W.
G	2.6	261	261¼	¼ W.
	5.5	265½		4¼ E.
	6.5	263½		2¼ E.
H	2.6	253	264¼	11¼ W.
	5.5	254½		9¾ W.
	7.5	255½		8¾ W.
I	2.6	272	265¼	6¾ E.
	5.5	274½		9¼ E.

The stations B, C, D, on the starboard side, show an average west deflection of 23°, the stations A and E, at the bow and stern, give 3° and 18° W. H, on the central line, gives 11° W. On the other hand, the port stations F, G, I, show either nearly no deflection or east deflection, (1° W, 0. 7° E.) The line of no deflection, 2 feet 6 inches, above the deck, runs, therefore, closely along the port side of the Passaic, (whereas on the Roanoke it was much more central.) As I had no opportunity of testing the position of this line with the heading of the vessel in the reverse direction, (or other directions,) it would, of course, not be safe to place a compass in the vertical plane of this line, as it appears from

the observations on the Roanoke that the line there shifted to some extent as shown in the annexed diagram. The nodal line is indicated by dashes.



R. heads SE. R. heads NW.

June 27.—The Passaic headed, from observations at the bow, 55° + 180° = 235°, and from observations at the stern 222½°, mean 229°, or NW ¼ W. In the captain's cabin, on the floor, the heading was 52° + 180° = 232°, deviation ¼ point E. On the table in the wardroom the bearings were 38° + 180° = 218° and 223°, mean 221°, deviation ¾ point W. Two feet above the table the bearings were 42° + 180° = 222° and 234°, mean 228°, deviation none. At the bow of the Passaic, at an elevation of 7 feet, there is no deviation; over B and D the W. deviation increases as we ascend, and at C and H, owing to the proximity of the turret, it diminishes with the height. If a compass is placed above the turret it should be well centred to its axis; thus over the circumference of the steering turret, at an elevation of 2 feet 6, the deviation is not less than 81°, and at an elevation of 5 feet 5 inches it is still 30°.

Very respectfully, yours,

CHARLES A. SCHOTT,
Assistant United States Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. C. S., Chairman Compass Committee.

APPENDIX A.

Deflections.—June 26.—Uniform distance of centre of magnets 45 divisions. First, observation with magnet E., N. end E. and W.; second, magnet W., N. end W. and E., with scale at right angle to meridian. Next magnet N., N. end E. and W.; magnet S., N. end W. and E., with scale in apparent (magnetic) meridian.

One set in each position was taken, first, at an elevation of 1 foot above deck; and secondly, at an elevation of 3 feet 7 inches, unless stated otherwise.

STATION A.

	Elevation.	*Deflections.* °	°	°	°	*Mean.*
Scale at r. a.	1 ft.	5¼	4¼	4¼	5	4.7
In mer......	1 ft.	¾	1	2¼	1½	1.4
Scale at r. a.	3 ft.7	4½	4	4¼	3½	4.1
In mer......	3 ft.7	1¾	2	2	1½	1.8

STATION B.

Scale at r. a.	1 ft.	6¾	6¼	5¾	6½	6.3
In mer.....	1 ft.	1	3½	3¾	1	2.3
Scale at r. a.	3 ft.7	1½	1¾	7	6¼	4.1
In mer.....	3 ft.7	2½	¾	5	2¾	2.8

STATION C.

Scale at r. a.	1 ft.	5¼	5½	5¾	7½	6.0
	3 ft.7	9½	6¼	7	5¾	7.1
In mer.....	3 ft.7	8	3¾	3¾	2¾	4.6

STATION D.

Scale at r. a.	1 ft.	9	6	6½	9¼	7.7
	3 ft.7	6¾	6½	4	7¼	6.1
In mer......	3 ft.7	3½	2¼	3	3¾	3.1

STATION E.

Scale at r. a.	1 ft.	7¾	7½	7	7¾	7.4
	3 ft.7	4¾	5	4¾	5½	5.0
In mer......	3 ft.7	2	½	2¾	3¼	1.9

STATION F.

Scale at r. a.	1 ft.	3½	4½	4½	3½	4.0
	3 ft.7	4	3¼	3¼	3½	3.5
In mer......	3 ft.7	1½	1½	1	2¼ (W=½)	1.6

STATION G.

Scale at r. a.	1 ft.	3	4¼	4½	4½	4.1
	3 ft.7	4¼	3½	3¼	4	3.7

STATION H.

Scale at r. a.	1 ft.	3½	7½	7	3½	5.4
	3 ft.7	4¾	5¼	5	5½	5.1

STATION I.

	Elevation.	*Deflections.* °	°	°	°	*Mean.*
Scale at r. a.	1 ft.	4½	5½	4½	3¾	4.6
	3 ft.7	3½	3½	4	4	3.7

STATION K.—In captain's cabin, (central between B and I.)

Scale at r. a.	3 ft.7	6½	4½	6	6¾	5.9
	2 ft.8 above floor	4¾	4½	5	3¾	4.5
	on floor	3	1	2½	¾	1.8

STATION L.—2 ft. from surface of turret, in central line to bow.

Scale at r. a.	3 ft.7	2	2½	2¼	3	24.

STATION M.—4 feet from surface of turret in central line to bow.

Scale at r. a.	3 ft.7	2½	4½	4¾	2¾	3.6

STATION N.—9 ft. from surface of turret, in central line to bow.

Scale at r. a.	3 ft.7	3½	4½	4½	3¼	3.9

STATION O.—In steering turret, top cover of turret *not* on.

Scale at r. a.	2 ft.3 below top	15	10½	10	14	12.4
In mer.....		6	7¼	6	4	5.8

STATION P.—In large turret, alongside smaller gun, midway between gun and side of turret.

Scale at r. a.	3 ft.7	15	13	10¼	14½	13.2

STATION Q.—On shore, (June 25.)

Scale at r. a.	3 ft.6	4¼	4½	3¾	4½	4.2
In mer.....	w = ¼	1¾	1	1½	1¼	1.4
Scale at r. a.	(distance 35)	8½	10¼	9¾	9	9.4
In mer......		4¼	6	5¼	4¼	4.9

Station.	Elevation 1 ft. r^3tg v.	Elev'n 3 ft. 7. r^3tg v.	Relat. X. Elev'n 1 ft.	Relat. X. El. 3 ft. 7.
A	5970	6130	1.15	1.12
B	8690	7710	0.79	0.89
C	9580	13000	0.72	0.53
D	12320	9800	0.56	0.70
E	11830	7010	0.58	0.98
F	6370	4560	1.08	1.50
G	6400	5890	1.07	1.16
H	8610	8000	0.80	0.86
I	7331	5890	0.93	1.17
K	El. 0 ft. 2860 El. 2–8 7170	9420	2.39 0.96	0.73
L	....	3820	....	1.79
M	....	5730	....	1.19
N	....	6210	....	1.10
O	....	19270	....	0.35
P	....	21370	....	0.32
Q	6847		1.00	

APPENDIX B.

Record and reduction of observations for relative total intensity.

Dip on shore station by position needle 1, (June 24,) 72° 33′.5.
Observations with Lloyd needle No. 1, (June 27.)
On shore station 4 feet 10 from ground.

Dip with weight.	59° 35′	59° 20′	Without weight..	72° 56′	73° 05′
	30	19		73 15	72 55
Mean.........	59° 26′			73° 03′	

STATION A.—10 inches from deck:

Without weight	74° 30′	72° 20′	With weight	58° 00′	57° 40′
	72 20	74 20		56 10	56 18
Mean	73° 22′			57° 02′	

STATION A.—4 feet 2 inches above deck:

With weight	55° 05′	55° 25′	Without weight	71° 10′	71° 00′
	54 25	54 30		69 08	69 13
Mean	54° 51′			70° 08′	

STATION A.—6 feet 10 inches above deck:

Without weight	74° 40′	74° 45′	With weight	59° 10′	59° 18′
	30	25		62 35	62 20
Mean	74° 35′			60° 48′	

STATION B.—10 inches from deck:

With weight	66° 35′	66° 40′	Without weight	77° 30′	77° 30′
	69 00	68 40		78 20	78 15
Mean	67° 44′			77° 54′	

STATION B.—4 feet 10 inches above deck:

Without weight	77° 00′	76° 45′	With weight	65° 00′	64° 55
	76 40	76 40		64 05	64 05
Mean	76° 46′			64° 31′	

STATION C.—10 inches from deck:

With weight	60° 40′	60° 38′	Without weight	76° 45′	76° 35′
	05	00		74 50	74 55
Mean	60° 21′			75° 46′	

STATION C.—4 feet 10 inches above deck:

Without weight	75° 50′	75° 55′	With weight	61° 40′	61° 45′
	40	40		30	22
Mean	75° 46′			61° 34′	

STATION D.—10 inches from deck:

With weight	71° 55′	71° 50′	Without weight	79° 50′	79° 50′
	70 40	70 35		80 40	80 25
Mean	71° 15′			80° 11′	

STATION D.—4 feet 10 inches above deck:

Without weight	76° 40′	76° 40′	With weight	64° 05′	65° 40′
	75 21	75 32		64 00	63 20
Mean	76° 03′			64° 16′	

STATION E.—10 inches from deck:

With weight	74° 50′	75° 02′	Without weight	81° 10′	81° 12′
	76 59	76 50		82 40	82 35
Mean	75° 55′			81° 54′	

STATION E.—4 feet 10 inches above deck:

Without weight	75° 34′	77° 20′	With weight	68° 10′	68° 04′
	77 34	75 50		66 18	66 20
Mean	76° 34′			67° 13′	

STATION F.—10 inches from deck:

With weight	57° 20′	56° 30′	Without weight	71° 40′	71° 55′
	55 05	55 20		73 00	72 30
Mean	56° 04′			72° 16′	

STATION F.—4 feet 10 inches above deck:

Without weight	67° 31′	66° 55′	With weight	47° 15′	47° 28′
	66 35	66 40		48 10	47 55
Mean	66° 55′			47° 42′	

STATION G.—10 inches above deck:

With weight	34° 45′	34° 45′	Without weight	66° 10′	64° 42′
	35 40	35 25′		64 40	65 45
Mean	35° 09′			65° 19′	

STATION G.—4 feet 10 inches from deck:

Without weight	66° 50′	66° 50′	With weight	38° 30′	38° 05′
	67 40	67 40		36 48	37 00
Mean	67° 15′			37° 36′	

STATION H.—10 inches above deck:

With weight	55° 20′	55° 40′	Without weight	72° 20′	72° 20′
	56 10	56 10		71 50	71 50
Mean	55° 50′			72° 05′	

STATION H.—4 feet 10 inches above deck:

Without weight	74° 30′	74° 15′	With weight	56° 00′	56° 00′
	73 00	73 10		10	10
Mean	73° 44′			56° 05′	

STATION I.—10 inches above deck:

With weight	56° 25′	56° 30′	Without weight	71° 30′	71° 30′
	30	30		30	20
Mean	56° 29′			71° 28′	

STATION I.—4 feet 10 inches above deck:

Without weight	69° 45′	69° 45′	With weight	52° 40′	51° 35′
	70 35	70 35		47 50	48 20
Mean	70° 08′			50° 06′	

STATION O.—Inside steering turret, (central,) turret open on top. (Elevation 4 feet 10.)

Without weight	76° 25′	76° 10′	With weight	+24° 40′	+24° 30′
	76 00	76 25		+23 20	+23 50
Mean	76° 15′			24° 05′	

STATION P.—Inside large turret, (elevation 4 feet 10.)

With weight	—74° 40′	—74° 55′	Without weight	50° 00′	49° 50′
	—79 00	—78° 45′		49 40	49 50
Mean	—76° 50′			49° 50′	

STATION L.—2 feet from turret, (elevation 4 feet 10.)

Without weight	42° 50′	41° 10′	With weight	—14° 00′	—0° 48′
	42 00	41 20		+0 52	+0. 30
Mean	41° 50′			—0° 16′	

STATION M.—4 feet from turret, (elevation 4 feet 10.)

With weight	+27° 10′	+27° 05′	Without weight	59° 55′	60° 10′
	+26 30	+26 50		60 00	10
Mean	26° 54′			60° 04′	

STATION N.—9 feet from turret, (elevation 4 feet 10.)

Without weight	60° 00′	60° 02′	With weight	35° 20′	33° 50′
	30	35		32 15	33 10
Mean	60° 17′			33° 39′	

STATION K.—In captain's cabin, 5 feet 6 inches above floor:

With weight	—46° 20′	—46° 25′	Without weight	34° 25′	33° 45′
	—46 20	—46 25		33 30	33 00
Mean	—46° 22′			33° 40	

STATION K.—4 feet 10 inches above floor:

Without weight	24° 50′	24° 40′	With weight	—52° 10′	—52° 35′
	20	20		—53 25	—53 10
Mean	24° 32′			—52° 50′	

STATION K.—2 feet 11 inches above floor:

With weight	—49° 00′	—49° 00′	Without weight	21° 25′	21° 30′
	—49 25	—49 20		21 40	21 35
Mean	—49° 11′			21° 32′	

STATION K.—11 inches above floor:

Without weight	29° 45′	29° 50′	With weight	—44° 00′	—43° 35′
	30 00	29 30		—43 25	—43 35
Mean	29° 46′			—43° 39′	

$$\varepsilon = \delta - \zeta = 72^\circ\ 33'.5 - 72^\circ\ 63' = -\ 29' \text{ (constant.)}$$

$$\varphi_1 = [9.65011]\ \frac{\cos\theta_1}{\sin(\delta_1 - \theta_1)}$$

Station.	ξ	δ	θ	$\delta-\theta$	$\frac{\phi_1}{\phi}$
	° ′	° ′	° ′	° ′	
On shore	73 03	72 34	59 26	13 08	1.00
A, 10 inches above deck	73 22	72 53	57 02	15 51	0.89
A, 4 feet 2 above deck	70 08	69 39	54 51	14 48	1.01
A, 6 feet 10 above deck	74 35	74 06	60 48	13 18	0.95
B, 10 inches above deck	77 54	77 25	67 44	9 41	1.01
B, 4 feet 10 above deck	76 46	76 17	64 31	11 46	0.94
C, 10 inches above deck	75 46	75 17	60 21	14 56	0.86
C, 4 feet 10 above deck	75 46	75 17	61 34	13 43	0.90
D, 10 inches above deck	80 11	79 42	71 15	8 27	0.98
D, 4 feet 10 above deck	76 03	75 34	64 16	11 18	0.99
E, 10 inches above deck	81 54	81 25	75 55	5 30	1.13
E, 4 feet 10 above deck	76 34	76 05	67 13	8 52	1.12
F, 10 inches above deck	72 16	71 47	56 04	15 43	0.92
F, 4 feet 10 above deck	66 55	66 26	47 42	18 44	0.94
G, 10 inches above deck	65 19	64 50	35 09	29 41	0.74
G, 4 feet 10 above deck	67 15	66 46	37 36	29 10	0.73
H, 10 inches above deck	72 05	71 36	55 50	15 46	0.92
H, 4 feet 10 above deck	73 44	73 15	56 05	17 10	0.84
I, 10 inches above deck	71 28	70 59	56 29	14 30	0.99
I, 4 feet 10 above deck	70 08	69 39	50 06	19 33	0.86
O, 4 feet 10 inside steering turret	76 15	75 46	24 05	51 41	0.52
P, 4 feet 10 inside large turret	49 50	49 21	—76 50	126 11	0.13
L, 4 feet 10, 2 feet from turret	41 50	41 21	— 0 16	41 37	0.67
M, 4 feet 10, 4 feet from turret	60 04	59 35	26 54	32 41	0.74
N, 4 feet 10, 9 feet from turret	60 17	59 48	33 39	26 09	0.84
K, 5 feet 6 above floor of captain's cabin	33 40	33 11	—46 22	79 33	0.31
K, 4 feet 10 above floor of captain's cabin	24 32	24 03	—52 50	76 53	0.28
K, 2 feet 11 above floor of captain's cabin	21 32	21 03	—49 11	70 14	0.31
K, 11 inches above floor of captain's cabin	29 46	29 17	—43 39	72 56	0.34

APPENDIX C.

Reciprocal bearings.—June 27.—Observations on board by myself; those on shore by Mr. Courtenay. Compasses Nos. 11 and 12*

STATION A.				STATION B.			
	Bearing of shore comp.	Reverse bearing.	Correct mag. bearing		Bearing of shore comp.	Reverse bearing.	Correct mag. bearing.
	°	°	°		°	°	°
At 2 ft. 6	267	91¼	270½	At 2 ft. 6	250	....	269
5 ft. 5	267	89¾	....	5 ft. 5	242½	89	....
8 ft. 5	269½	86	266	7 ft. 5	244	88¾	....
STATION C.				**STATION D.**			
At 2 ft. 6	231	86¼	266¼	At 2 ft. 6	244	79¼	259¼
5 ft. 5	241	86½	....	5 ft. 5	235	79¼	....
7 ft. 5	244	86¼	....	8 ft. 5	231	....	....
STATION E.				**STATION F.**			
At 2 ft. 6	238	76½	256½	At 2 ft. 6	254½	75⅝	255⅝
5 ft. 5	232	76¼	....	5 ft. 5	255½	75¾	....
6 ft. 5	238	77	....	....	....	....	....
STATION G.				**STATION H, between B and I.**			
At 2 ft. 6	261	81½	261¼	At 2 ft. 6	253	84½	264¼
5 ft. 5	265½	81	....	5 ft. 5	254½	84	....
6 ft. 5	263½	81½	....	7 ft. 5	255½	84¼	....

* They read from S. to E., &c., to [illegible]

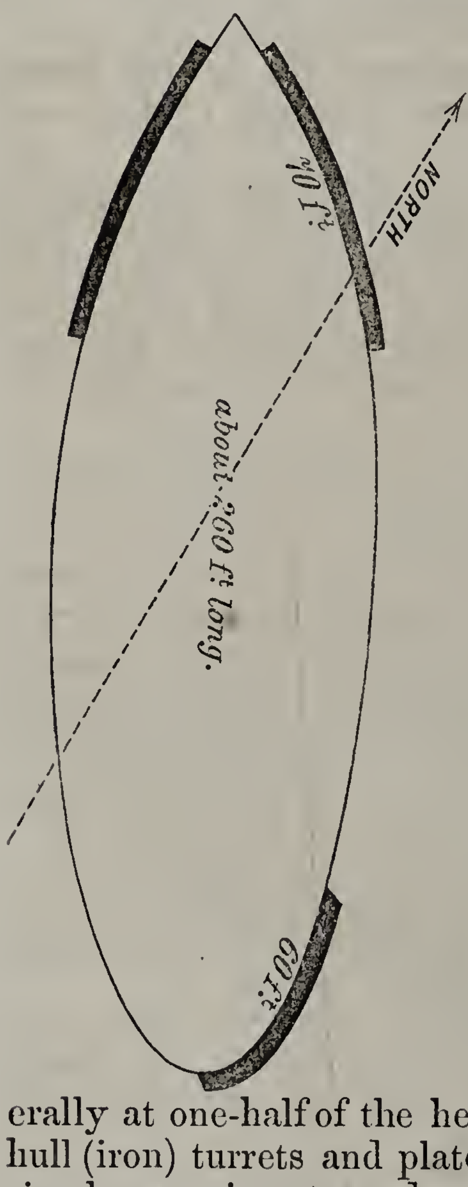
STATION I.				TOP OF STEERING TURRET ON CIRCUMFERENCE.			
At 2 ft. 6......	272	85½	265¼	At 2 ft. 6....	346	85½	265¼
5 ft. 5......	274½	85¼	....	5 ft. 5....	295½	85	....

N. B.—Could not observe the axis of the turret, as the top was not on.

Appendix D.

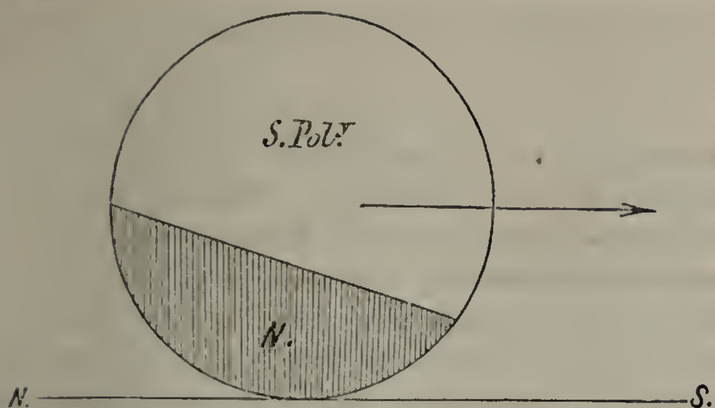
Experiments made at the Monadnock, on the stocks at the Charlestown navy yard, July 3, 1863.

She has a wooden hull and but a small portion of her side armor was put on



The heavy lines in the diagram exhibit the amount of top-plating already put on. Heading of vessel NW. nearly. Height of plates 4 feet, length 5 feet, thickness 1 inch. This vessel will probably be provided with two turrets. Total thickness of armor 5 inches. Unless the armor is connected all round, the magnetic distribution will not assume that static condition which it is desirable to examine. On the top the plates are S. magnetic. On the starboard plates, near the bow, the N. polarity changes into S. polarity 1 foot 6 inches from bottom, (2 feet at seam, which is close;) nearer to the bow the changes take place 2 feet from bottom, (3 feet 1 inch at seam.) On the port side plates N. polarity is predominant, nearest to the bow, 5 inches from top, (where it is S.,) it changes to N.; further from bow change to N. 2 feet 6 from top; in third plate from end the change takes place 4 inches from bottom, and the last two plates show S. polarity all over. Of the stern plating, that nearest to it was S. magnetic, single, double, and triple plates. Further on, the strip of N. polarity at bottom increased from ½ inch to 1 foot 9 and 2 feet 5, and the last plate on the starboard side had N. polarity to within 3 inches of the top. Of a number of plates standing about the ship-house, the change from S. to N. polarity (bottom) took place generally at one-half of the height. The general distribution of the polarity of the hull (iron) turrets and plates is well illustrated and explained by the following simple experiments made at the yard:

Taking a soft iron bolt 2 feet 6 inches long and 1 inch in diameter, and holding it vertical, the lower end for 1 foot 1, showed N. polarity, the upper end S. polarity; now inverting it quickly the N. polarity of the former lower end, but now the upper, had changed to S. polarity. Holding the bolt in a direction parallel with the dipping needle, the intensity was stronger than before, and the change of polarity, after reversal of ends, was equally instantaneous. Holding it level and perpendicular to the magnetic meridian, the side turned towards the N. was N. magnetic, the opposite side (all along its length) was S. magnetic; turning it round its longitudinal axis no change was produced in the polarity. Balls and shells of various sizes were examined. Taking a 10-inch shell, the S. polarity



commenced 2 inches from botton on the S. side, and 5 inches from bottom on the N. side, in the magnetic meridian. Rolling this shell along the meridian line traced out in the ground, (towards the south,) I could not roll it fast enough to make the N. polarity rise; it always showed S. polarity on the top half. A similar observation as to the time required for induction was made on a wooden roller with an iron band on one end. Turning it as fast as could be done by hand, the distribution of the polarity on the band remained the same.

C. A. S.

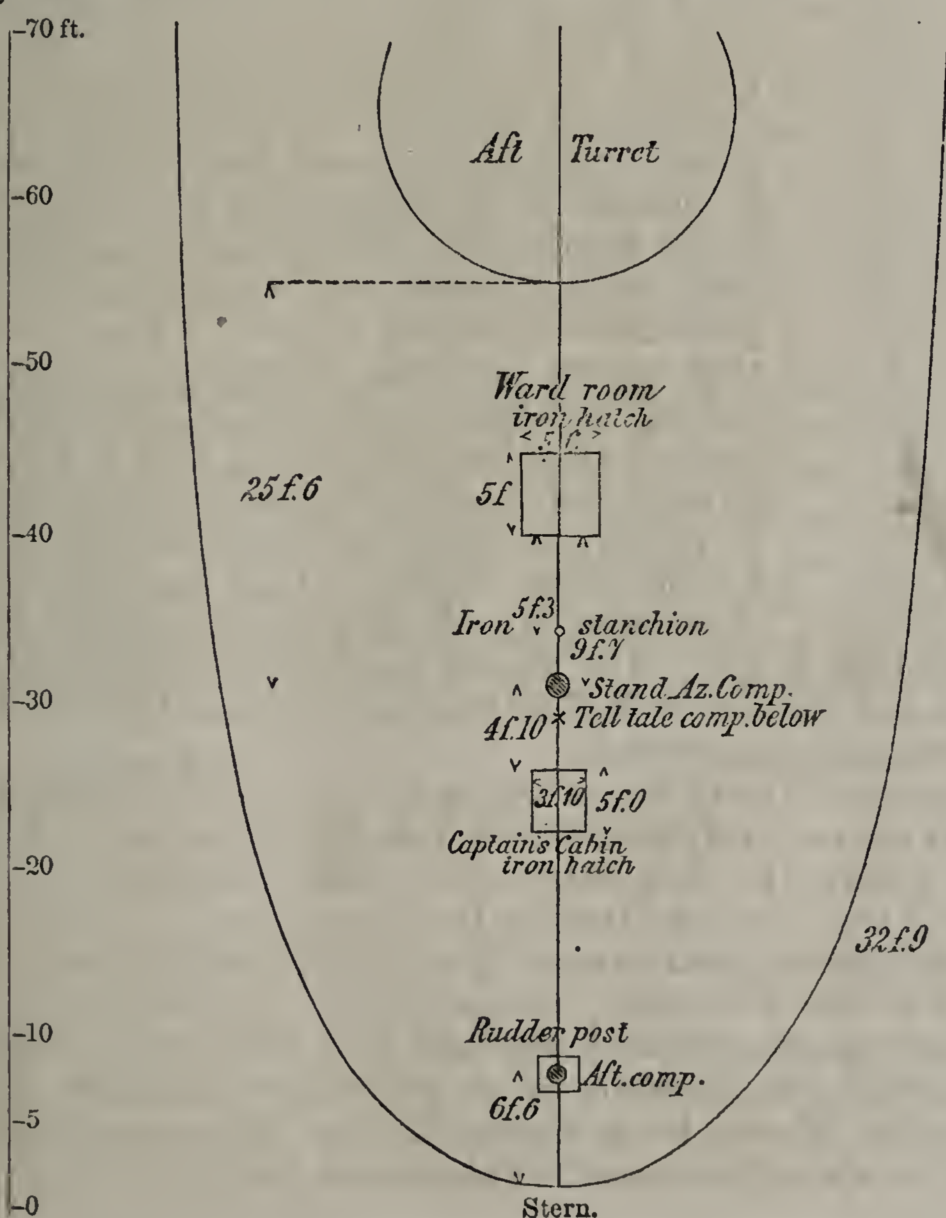
Appendix No. 7.

FOURTH REPORT TO COMPASS COMMITTEE.

Examination of the deviation of the compasses on board the United States steamer Roanoke, James river, Virginia, in November, 1863, *by C. A. Schott, Assistant Coast Survey.*

Coast Survey Office, *December* 19, 1863.

Dear Sir: In accordance with your instructions, received in October last, to ascertain the deviation of the compasses of the iron-clad steamer Roanoke, and to test the cabin compass, with and without its adjustment, I made a series of observations November 18, 19, and 20, the results of which are herewith respectfully submitted.



The following general arrangement was adopted to secure the requisite observations:

An azimuth compass was mounted on deck at an elevation of 4 feet 10 inches, in the midship line, and between the captain's cabin and the wardroom hatches, as shown in the diagram. The fore-and-aft line was, by measure, carefully traced out, and the lubber line of the azimuth compass placed in it. The other compasses were found located as follows: One at six and a half feet from the stern on deck (card about one foot above deck,) and near the rudder post; a second one, tell-tale compass, in the captain's cabin; a third one, above the middle turret, seen by reflectors, and about twenty-one feet above deck; and a fourth one, above forward turret, fluid compass, at about the same elevation above deck as the preceding one. At each compass an officer was stationed, who noted the heading of the vessel each time the signal was given by the striking of the ship's bell. In this way simultaneous readings were secured with those taken by myself with the standard compass. The deviations of the standard compass from the bearings of a distant object being known, those of the other compasses were easily derived from it. To obtain the correct magnetic bearing of this object, three methods were employed: the first, by means of astronomical azimuths of the sun, the latitude, time, and magnetic declination being known; the second, by means of compass directions, measured to five objects on shore, and plotting the angles on our chart of Hampton Roads and James river entrance, 1863; and the third, by means of the observed magnetic bearings themselves. The resulting deviations of the compasses, as the vessel swung round, are given in tabular form and also graphically, the latter on the convenient diagrams, known as Napier's. These have been reproduced by this office. It is hardly necessary to state that I made use of the second edition of the admiralty's manual on the deviations of the compass, (London, 1863.)

The azimuth compass at my disposal was an indifferent one, requiring much care to secure the correct bearing within about three-fourths of a degree. The current reversed in about one hour, and as slack-water occurred near the middle of the day, only one tide a day could be used. On the first day observations extended over half a circle; on the second day a trial was made to turn the vessel through 360° by the aid of two steam-tugs, but they could not accomplish it; on the third day, fortunately, favored by a strong breeze, the vessel swung in the opposite direction, thus completing the heading for every point of the circle.

The left-hand tangent on the Rip Rips was used as the line of comparison for the bearings. The distance from the anchorage is seven and a quarter statute miles, and as the Roanoke had forty-five fathoms of chain out in thirty-seven feet water, and the standard azimuth compass was 251 feet aft, the circle in which this compass swung subtended an angle of 1° 32′ at the Rip Raps, and consequently m de it desirable to allow for the various bearings accordingly. The co rect mag etic bearing of the Rip Raps from the azimuth observations of the sun, the known time and variation, was found by computation:

At ebb tide.		*At flood tide.*	
Nov. 18	N. 76° 59′ E.	Nov. 18	N. 77° 56′ E.
20	76 34	19	77 08
Mean	76 46	Mean	77 32

Mean or correct bearing from the anchorage N. 77° 09′ E. In these computations the variation has been taken 1° 32′ W., as resulting from my observations at Fortress Monroe in 1856, and brought up to date by allowing an annual increase of 2½′. (For record see Appendix No. 1.)

The plotting of the four angles on the accompanying chart gives the true bearing of the line from the anchorage .... N. 75° 30′ E.
Correction for variation .... +1 32
Correct magnetic bearing .... N. 77° 02′ E.
(For record see Appendix No. 2.)

By interpolating for each of the thirty-two points the observed bearing by disturbed compass, and taking the mean, a close approximation is obtained of the correct magnetic bearing. I find N. 76° 35′ E. This includes any irregularities in the effect of the ship's iron, and any error that may possibly be in the position of the lubber line. We then have correct magnetic bearing of Rip Raps:

Astronomically .... N. 77° 09′ E
Geodetically 77 02
Magnetically 76 35

and giving the last value the weight one-half the adopted bearing becomes N. 76° 59′ E.

DEVIATION OF STANDARD COMPASS.

From observations of November 18 and November 20, and two on November 19, the following table of deviations was made up. The numbers in column "correct magnetic bearing of Rip Raps" are correct for position in the circle of rotation:

	Ship's head by (disturbed) stand. compass.	Observed bearing of R. R.	Correct magnetic bearing of same.	Deviation of standard compass.
November 18, 1863	N. 4° 00′ E.	N. 82° 00′ E.	N. 76° 15′ E.	5° 45′ W.
	15 30	85 10	76 17	8 53
	22 15	81 50	76 19	5 31
	34 00	82 30	76 29	6 01
	47 30	80 50	76 41	4 09
	56 00	78 00	76 44	1 16
	69 00	*81 34	76 53	4 41
	E.	*82 04	77 14	4 50
	S. 78 00 E.	*86 34	77 15	9 19
	68 50	*86 44	77 19	9 25
	56 00	84 30	77 29	7 01
	45 00	83 30	77 39	5 51
	34 00	81 00	77 42	3 18
	26 47	79 30	77 43	1 47
	26 30	79 30	77 43	1 47
November 20, 1863	21 30	77 20	77 45	0 25 E.
	16 00	76 20	77 44	1 24
	10 00	73 00	77 43	4 43
	S.	71 00	77 43	6 43
	S. 10 00 W.	66 50	77 42	10 52
	23 50	63 40	77 39	13 59
	35 20	62 50	77 29	14 39
	46 40	61 40	77 19	15 39
	66 00	61 30	77 09	15 39
	76 00	63 20	76 59	13 39
	N. 89 50 W.	68 00	76 44	8 44
	77 00	71 00	76 37	5 37
	65 50	72 15	76 29	4 14
	38 50	84 55	76 18	8 37 W.
	33 40	83 50	76 17	7 33
November 19, 1863	24 20	86 32	76 13	10 19
	21 52	84 58	76 13	8 45
November 18, 1863	21 29	87 12	76 13	10 59

The bearings marked with an asterisk (*) were not directly observed, (the turret and other objects being in the way;) the quantities are given in Appendix No. 4. The aft hatch was lowered during the above observations.

The red curve on diagram No. 1 represents this deviation of the standard compass. As I have found by experiment (see Appendix No. 5) that the condition of the iron hatch, whether lowered or raised, considerably affected the

standard compass, a second set of observations was made on the 19th, showing the deviations of the standard compass with the hatch raised; these were especially designed to find the deviations of the cabin compass under this condition.

The first column of the next table contains the bearing of the ship's head by (disturbed) azimuth compass; the second column contains the corresponding correct magnetic bearing; in the remaining columns the corresponding readings of the other four (disturbed) compasses have been inserted. The hatch was lowered in all these experiments.

Bearing of ship's head.

By disturb'd stand. compass.	Cor'ect bearing by stand. comp.	By disturb'd aft deck compass.	By disturbed tell-tale cabin compass.	By disturbed middle turret compass.	By disturbed forward turret compass.
N. 4° 00′ E.	N. 2° W.	N. ⅞ W	*N. ⅜ E. to N. ½ E	N	N. ¼ E.
15 30	N. 7 E.	N. ¾ W	*N. by E. ¾ E	N. 5° E.	N. ½ E.
22 15	17	N. ¾ E.	*NNE. ⅞ E. to NNE. ¾ E.	N. by E. ¼ E.	N. by E. ¾ E.
34 00	28	NNE. ¼ E.	*NE	NNE. ¼ E.	NE. ¾ N.
47 30	43	NE. ⅛ N.	*NE. by E. ⅛ E. to NE. by E.	NE. ¼ N.	NE. ½ E.
56 00	55	NE. by E. ¼ E.	*ENE. ¼ E	NE. ⅛ E. 2° E.	ENE.
69 00	64	E. by N.	*E ⅞ N. to E. ¾ N	ENE. 2° N.	E. by N.
E.	85	E. ½ S	*E. ½ S	E. ¼ N. 1° N.	E. ¾ S
S. 78 00 E.	S. 87 E.	E. by S. ¼ S.	*E. by S. ⅛ S. to E. by S. ¼ S.	E. ¼ S	E. by S. ½ S.
68 50	78	ESE. ¼ S	*ESE. ⅛ E	E. by S. 2° S.	SE. by E. ½ E.
56 00	63	SE. ¾ E.	*SE. by E. ⅛ E.	SE. by E. ½ E.	SE. ½ E.
45 00	51	SE. ¼ S.	*SE. ¼ E	SE. ⅛ E.	SE. ¼ S.
34 00	37	SE. by S. ½ S.	*SE. ⅝ S. to SE. ¾ S.	SE. ½ S	SE. by S. ½ S.
26 47	29	SSE	*SSE. ⅞ E. to SSE. ¾ E.	SE. by S. ½ S	SSE
26 30	28	...	...	...	...
21 30	21	S. by E.	SSE. ½ S SSE. 1-16 S *SE. by S. ⅛ S	SSE. ¼ E.	S. by E. ½ E.
16 00	15	S. ½ E.	S. by E.	S. by E. 1° E.	S. by E.
10 00	5	S. ½ W.	S. ¼ E.	S.	S.
S.	S. 7 W.	S. ¾ W.	S. ½ W.	S. ½ W. 2° W.	S. ½ W.
S. 10 00 W.	21	S. by W. ¾ W.	SSW. ½ S.	SSW. 1° W.	S. by W. ½ W.
23 50	38	SSW. ¼ W.	SSW. ¼ W	SW. by S.	SW. by S. ½ S.
35 20	50	SW. ¾ S.	SW. ¾ S.	SW. 2° W.	SW. ¼ S.
46 40	62	SW	SW. ¼ W.	SW. by W. ¼ W.	SW. by W. ½ S.
66 00	82	SW. by W. ½ W.	WSW	W. by S. ¼ S.	WSW
76 00	W.	W. by S. ¾ S.	W. by S. ¼ S	W. ¼ S. 2° S.	W. by S. ¼ S.
N. 89 50 W.	N. 81 W.	W. by S.	W. ⅛ S	W. ¾ N.	W. ¼ S
77 00	71	W. ¼ S.	W. by N.	WNW. 2° W.	W. ½ N.
65 50	62	W. ½ N.	WNW. ¼ W	NW. by W. ½ W.	W. by N. ¼ N.
40 30	(50)	...	*NW. ⅞ N. *NW. ⅛ W	...	...
38 50	47	WNW. ¼ N. NNW	NW. ¼ N. NW. 1-16 N.	NW. ¼ N. 1° N NW. ¼ N. 2° N.	NW. ½ W.
33 40	41	...	NW. ¼ N. (?)	...	...
24 20	35	NW. by W. ⅛ W.	*N. by W. ⅞ W	†NNW. ½ W.	NW. by N.
21 52	31	...	...	...	...
21 29	32	...	...	...	...

† Ship swinging.

Now, if there was no deviation in the four compasses, the bearings in each horizontal line of the last five columns ought to be the same, the actual differences from column two or the deviations are given in the table below. The readings by the tell-tale compass, to which an asterisk is prefixed, are those when the magnet intended for compensation was in its place; those without the asterisk were taken with the magnet removed.

Cor'ect magnetic bearing of ship's head.	Deviation of—				
	Aft deck compass.	Tell-tale compass with magnet.	Tell-tale compass without magnet.	Middle turret compass.	Forward turret compass.
N. 2° W.	8° E.	7° W.	....	2° W.	5° W.
N. 7 E.	15	13	....	2 E.	1 E.
17	9	15	....	3	3 W.
28	3	17	....	0	9
43	1 W.	14	....	1	8
55	4	15	....	4	12
64	15	17	....	1 W.	15
85	11	11	....	1	13
S. 87 E.	11	11	....	0	14
78	13	9	....	1	16
63	10	5	....	1	12
51	9	3	....	2	9
37	9	0	....	2 E.	9
29	7	3 E.	....	1 W.	7
28	....	....	....	....	....
21	10	11	3 W.	1	4
15	9	....	4	3	4
5	11	....	2	5	5
S. 7 W.	1	....	2 E.	1	1 E.
21	1 E.	....	4	2	4
38	13	....	13	4 E.	10
50	13	....	13	3	8
62	17	....	14	3	11
82	20	....	15	6	15
W.	20	....	14	5	14
N. 81 W.	20	....	10	1	12
71	22	....	8	1 W.	13
62	22	....	3	0	14
(50)	....	9 W.	....	....	....
47	20	....	4 W.	2 E.	4
41	....	....	....	....	....
35	23	14	....	....	1 W.
31	....	....	....	....	....
32	....	....	....	....	....

Diagram No. 2 represents the above deviations of the tell-tale compass with the magnet, and also without the magnet, and diagram No. 3 exhibits the deviations of the aft deck and the turret compasses.

The following observations, of November 19, were made when the iron hatch was up or closed, in order to test its effect upon the cabin compass.

	Ship's head by disturbed standard compass.	Observed bearing of Rip Raps.	Correct magnetic bearing of the same.	Deviation of stand. compass. (Hatch up.)
November 19, 1863..............	N. 27° 30′ W.	N. 79° 20′ E.	N. 76° 15′ E.	3° 05′ W.
	18 50	82 50	76 13	6 37
	N. 5 00 E.	87 40	76 15	11 25
	[N. 14 30 E.]	[87 50]	76 17	11 33
	22 30	88 00	76 19	11 41
	49 00	S. 87 30 E.	76 49	15 48
	67 00	86 30	76 51	16 39
	†88 50	*84 50	77 12	17 58
	S. 68 00 E.	*83 35	77 19	19 06
	49 00	87 20	77 35	15 05
	22 00	N. 84 20 E.	77 45	6 35
	10 40	78 40	77 43	0 57
	2 30	72 40	77 43	5 03 E.

The two values within brackets are interpolated.

* These bearings were indirectly observed, as the turret was in the way.
† Probably 84° 50′, card swinging.

Tree S. 79° 00′ E.	R. R. N. 80° 20′ E.	∠ Tree and R. R. 20° 40′
78 30	80 20	Tree S. 64° 10′ E.
	81 30	
78 45	80 10	R. R. S. 84° 50′ E.
	80 35	

Nansemond	S. 40° 30′ W.	∠ Nanse. and R. R.	139° 15′
	39 10	Nanse.	S. 55° 40′ W.
	39 50	R. R.	83 35

The observed deviation of the standard compass (with hatch up) is shown on diagram No. 1, dotted curve.

From simultaneous readings of the other compasses, the following additional deviations have been obtained. For the observations see Appendix No. 6.

Cor'ect magnetic bearing of ship's head.	Deviation of—			
	Aft deck compass.	Tell-tale compass with magnet.	Middle turret compass.	For'ard turret compass.
N. 31° W.	....	....	....	....
25	17° E.	17° W.	5° W.	0
6	16	12	0	0
N. 3 E.	14	17	3	3° W.
11	11	17	0	3
33	9 W.	18	6	12
50	10	15	6	15
71	13	12	3	15
(—4)				
S. 87 E.	17	11	1	17
64	13	5	5	16
29	4	5 E.	1	9
12	4	8	1	4
S. 3 W.	0	14	2 E.	0

The deviations of the tell-tale compass are given on diagram II, and those of the other compasses on diagram III.

From the preceding deviation tables, or from the diagrams I, II, III, we draw the following general conclusions:

With the ship heading to the *eastward* all the compasses deviate to the *west*, and with the head to the *westward* all deviations are to the *east*.

The neutral directions are approximating to the north and south.

If the rule found from similar investigations made in England applies in our case, it would indicate that the Roanoke headed nearly NNW. at the time when the armor plates were put on.*

The deviations of the middle turret compass are the least, hardly exceeding one-third of a point; the other compasses deviate as much as one and a half point. In this connexion it should be stated that the middle turret compass and the forward turret compass are both about $20\frac{1}{2}$ feet above deck.

The uncertainty in the determination of a deviation is about $\frac{3}{4}$ of a degree for the standard compass, and about two degrees for the other compasses, (some not being read nearer than $\frac{1}{4}$ of a point.)

Whether we use the full or dotted curve of the standard compass, the deviations of the other compasses, depending upon those, come out the same within the stated uncertainties, as they should do.

The cause of the apparent inflexion of the full curve of the standard compass (diagram I) must be sought in the effect of the lowered iron hatch; when it was raised the curve became normal.

On diagram II we notice a very close correspondence of the dotted and dashed curves, showing that the hatch, whether open or closed, did not affect the cabin compass. The only change, in reference to this compass, when the hatch is raised, is to raise also the neutral line, in which case a strong S. polarity becomes opposed to the standard compass. The same two curves also indicate that, though the adjusting magnet was in its place, the compass still deviated,

* The committee can, no doubt, easily obtain the desirable information.

when heading NE., as much as a point and a half; without this magnet, when heading S.W., the greatest deviation was one and a quarter point.

For the purpose of a ready comparison with similar investigations, and to obtain a better view of the separate effect of the iron of the ship upon the compasses, it is necessary to express their deviations analytically. According to the theory given in the Admiralty's Manual, we have the deviation $\delta = \zeta - \zeta^1$ expressed with sufficient accuracy (the coefficients not exceeding 20′) by the formula—

$$\delta = A + B \sin \zeta^1 + C \cos \zeta^1 + D \sin 2 \zeta^1 + E \cos 2 \zeta^1$$

The deviations for each compass and each point, setting out from the disturbed or compass courses, are given in Appendix No. 7; they have been made out from the Napier diagrams.

Let δ_1 indicate the deviations of the aft deck compass.
δ_2 indicate the deviations of the cabin tell-tale compass without the magnet.
δ_3 indicate the deviations of the standard compass on deck.
δ_4 indicate the deviations of the middle turret compass.
δ_5 indicate the deviations of the forward turret compass.

We then have the following numerical results, remarking that those for δ_2 are only approximate, as the vessel was not swung through the whole circle, with the magnet off:

$$\delta_1 = +\ 4^\circ\ 5' - 17^\circ\ 35' \sin \zeta^1 + 4^\circ\ 43' \cos \zeta^1 + 0^\circ\ 38' \sin 2 \zeta^1 - 0^\circ\ 27' \cos 2\zeta^1$$
$$\delta_2 = -\ 3\ \ 9 - 12\ \ 30 \sin \zeta^1 - 6\ \ 23 \cos \zeta^1 + 2\ \ 27 \sin 2 \zeta^1 - 0\ \ 45 \cos 2\zeta^1$$
$$\delta_3 = +\ 0\ 29 - 7\ \ 50 \sin \zeta^1 - 8\ \ 00 \cos \zeta^1 + 5\ \ 40 \sin 2 \zeta^1 - 1\ \ 19 \cos 2\zeta^1$$
$$\delta_4 = -\ 0\ 27 - 2\ \ 24 \sin \zeta^1 - 0\ \ 29 \cos \zeta^1 + 0\ \ 42 \sin 2 \zeta^1 - 0\ \ 46 \cos 2\zeta^1$$
$$\delta_5 = -\ 2\ 14 - 13\ \ 33 \sin \zeta^1 - 0\ \ 59 \cos \zeta^1 + 2\ \ 56 \sin 2 \zeta^1 - 0\ \ 44 \cos 2\zeta^1$$

REMARKS IN REGARD TO COEFFICIENTS.

To A. Is large for aft deck and tell-tale compasses, partly the effect of index error, partly that of soft iron; the forward turret compass is probably affected with index error alone.

To B. For an iron-clad and turreted vessel the amount is small. The negative sign indicates that the Roanoke was probably built (plated) head to the north. The small value for the middle turret is not due to elevation, as the equally elevated forward turret shows a much greater value. The negative sign also indicates an attraction of the north point of the compass to the stern.

To C, the second part of the semicircular deviation. The values are of ordinary magnitude, and the sign, at least for four localities, indicates that the ship headed westerly when plated, and that the north point of the compass is attracted to the port side.

To D, first part of the quadrantal deviation. This coefficient has, with rare exceptions, a positive value, as also in the present case. The amount for the standard compass is the only large value, no doubt due to the induction of the soft iron (tested to be such) of the hatches.

To E. This coefficint should, in general, be smaller than D; it rises only in the case of the standard compass to any considerable amount, and is explained in the same way as the corresponding large value of the other coefficient of the quadrantal deviation.

I conclude this report with a steering table for each compass, and adapted to the magnetic latitude 69½°, the dip at the mouth of the James river.

Steering table.

Correct magnetic course proposed to be made.	Course to be steer'd by aft compass.	Course to be steer'd by tell-tale compass with magnet.	Course to be steer'd by tell-tale compass without magnet.	Course to be steer'd by middle turret compass.	Course to be steer'd by forward turret compass.
N	N. by W. ⅛ W	N. by E. ⅛ E		N. ⅛ E	N. ¼ E
N. by E	N	NNE. ⅜ E		N. by E. ⅛ N	N. by E. ⅛ E
NNE	NNE. ¼ N	NE. ½ N		NNE. ⅛ E	NE. by N. ⅜ N
NE. by N	NE. ½ N	NE. ½ E		NE. by N. ¼ E	NE
NE	NE. ½ E	NE. by E. ⅜ E		NE. ¼ E	NE. by E
NE. by E	NE. by E. ¾ E	ENE. ¼ E		NE. by E. ⅛ E	ENE. ¼ E
ENE	E. by N. ⅛ E	E. by N. ¼ E		ENE. ⅛ E	E. ⅝ N
E. by N	E. ¼ S	E. ⅛ S		E. by N. ⅛ E	E. ⅜ S
E	E. by S. ¼ S	E. by S		E. ⅛ S	E. by S. ⅜ S
E. by S	ESE. ⅜ S	ESE. ¼ E		E. by S. ⅛ S	ESE. ⅜ S
ESE	SE. by E. ⅛ S	ESE. ½ S		ESE. ¼ S	SE. ¾ E
SE. by E	SE	SE. by E. ¼ S		SE. by E. ¼ S	SE. ⅛ E
SE	SE. by S. ¼ E	SE. ⅛ S		SE. ⅛ S	SE. by S
SE. by S	SE. by S. ⅝ S	SE. by S. ⅛ E		SE. by S	SSE. ⅛ E
SSE	SE. by E. ⅜ E	SE. by S. ¼ S	SSE. ¼ S	SSE. ⅛ S	SSE. ½ S
S. by E	S. ⅜ E	SSE. ¼ S	S. by E. ¼ S	S. by E. ¼ S	S. ⅝ E
S	S. ¼ W	S. by E. ⅛ E	S	S. ¼ W	S. ⅛ W
S. by W	S. by W		S. by W. ¼ S	S. by W. ⅛ W	S. by W. ⅛ S
SSW	SSW. ¼ S		SSW. ⅜ S	SSW. ⅛ W	SSW. ⅜ S
SW. by S	SSW. ⅛ W		SSW. ⅛ W	SW. by S. ⅛ S	SW. by S. ¾ S
SW	SW. by S. ⅛ S		SW. by S ⅛ S	SW. ¼ S	SW. ⅞ S
SW. by W	SW. ⅜ S		SW. ⅛ S	SW. by W. ¼ S	SW. ¼ S
WSW	SW. ½ W		SW. by W. ¼ S	WSW. ⅜ S	SW. by W
W. by S	SW. by W. ¼ W.		WSW. ¼ S	W. by S. ½ S	WSW. ¼ S
W	WSW. ¼ W		W. by S. ¼ S	W. ½ S	W. by S. ¼ S
W. by N	W. by S. ¼ W		W. ⅛ N	W. by N	W
WNW	W		W. by N. ½ N	WNW	W. by N. ⅛ N
NW. by W	W. by N. ⅛ N	NW. ⅜ W	NW. by W	NW. by W	WNW. ⅛ N
NW	WNW. ¼ N	NW. by N	NW. ½ N	NW	NW. ¼ W
NW. by N	NW. by W. ⅛ N.	N. by W. ½ W		NW. by N. ⅛ N	NW. by N. ⅛ N
NNW	NW. ½ N	N. by W. ¼ N		NNW. ¼ N	NNW. ¼ N
N. by W	NNW. ¼ W	N		N. by W. ⅛ N	N. by W. ¼ N
N	N. by W. ⅛ W	N. by E. ⅛ E		N. ⅛ E	N. ¼ E

For the forward turret compass I also present a steering dygogram. Its eccentric four-cusped figure, when constructed for a number of compasses, serves to exhibit to the eye the peculiarities of their deviations; the elongated shape in the present case is due to the value of A. Cutting out the four-cusped figure and pasting it on the face of the compass, (in its proper position and proportionally enlarged, if the compass card is greater,) the vessel can be correctly steered, with the advantage that we can by inspection, at any time, know the correct magnetic and compass course as well as the deviation. The principle of Ritchie's compass, however, does not admit of the use of such a diagram.

I remain, sir, yours, very respectfully,

CHARLES A. SCHOTT,
Assistant United States Coast Survey.

Professor A. D. BACHE,
Superintendent United States Coast Survey,
Chairman Compass Committee.

APPENDIX No. 1.

Latitude, 36° 57′ 25″; longitude, 76° 25′ 20″; both from chart.

Double alt. of ⊙ November 18, p. m.

By hack watch.			Index error 1′ on.		
h.	*m.*	*s.*	°	′	″
1	37	29	55	22	10
	38	33.5		9	00
	39	38.5	54	55	20
	40	43		42	20
	41	29.5		31	50
1	39	34.7	54	56	08

Hence ⊙ alt. 27° 42′ 04″ and by $\sin \frac{1}{2} t = \sqrt{\dfrac{\sin\left(\dfrac{z+(\varphi-\delta)}{2}\right)\sin\left(\dfrac{z-(\varphi-\delta)}{2}\right)}{\cos\varphi\cos\delta}}$

H. watch fast of *mean* t. 24*s*., and pocket w. slow $1\frac{1}{2}$ *m.*

November 18, *A. M.*

Compass bearing of ⊙, by pocket w.: Ebb.					Bearing of R. R. (tg.)	
	h.	*m.*	°	′	°	′
	11	10	S. 2	35 W.	N. 86	30 E.
		15	2	50	85	50
		20	5	00	87	10
		25	6	35	87	00
		30	8	00	87	30
					87	40
Mean	11	20	S. 5	00 W.	88	00
	+	1.5			88	00
					87	12

$$\text{Hence by } \operatorname{tg} \tfrac{1}{2}(A+S) = \cot \tfrac{1}{2} t \, \frac{\cos \frac{1}{2}(\Delta-\lambda)}{\cos \frac{1}{2}(\Delta+\lambda)}$$

$$\operatorname{tg} \tfrac{1}{2}(A-S) = \cot \tfrac{1}{2} t \, \frac{\sin \frac{1}{2}(\Delta-\lambda)}{\sin \frac{1}{2}(\Delta+\lambda)}$$

$$A = \tfrac{1}{2}(A+S) \pm \tfrac{1}{2}(A-S)$$ Heading N.

True bearing of ⊙	S.	6°	45′ E.
Observed ∠ ⊙ and R.R.		97	48
True bearing of R.R.	N.	75	27
Variation,		1	32
Correct magnetic bearing R.R.		76	59

November 18, *P. M.* *Flood.*

	h.	*m.*	°	′		° ′	° ′
	0	45	S. 21	00 W.	Bearing of R.R.	N. 81 20 E.,	N. 78 20 E.
		50	21	20		80 40	79 10
		55	22	20		79 20	79 20
	1	00	24	00		78 30	79 20
Mean	1	52.5	S. 22	10 W.		N. 79 30 E.	

Whence true az. of ⊙	19° 04′	Heading S.SE.
∠ R.R. and ⊙	122 40	

True bearing of R.R.,	N. 76° 24′ E.	
Variation,	1 32	
Correct magnetic bearing	77 56	

November 19, *P. M.*	⊙	*Flood.*
2*h.* 27*m.*	S. 46° 20′ W.	R.R., N. 81° 30′ E.
32	46 50	80 10
37	48 40	80 20
42	50 10	80 20
Mean 2 34.5	48 00	80 35
Whence true az. of ⊙	S. 43° 01′ W.	Heading S.
∠ R. R. and ⊙	147 25	
True bearing of R. R.	N. 75 36 E.	
Variation,	1 32	
Correct magnetic bearing	77 08	

November 20, *P. M.*	⊙	*Ebb.*
1*h.*13*m.*	S. 33° 10′ W.	R. R. N. 83° 40′ E.
18	34 10	84 00
23	36 20	
53	41 40	83 50
		Heading NW. by N.
1. 26.7	S. 36 20 W.	
Whence true az. of ⊙	S. 27° 32′ W.	
∠ R. R. and ⊙	132 30	
True bearing of R. R.	N. 75 02 E.	
Variation,	1 32	
Correct magnetic bearing	76 34	

Appendix No. 2.

OBSERVED BEARINGS WITH STANDARD COMPASS FOR POSITION AT SLACK-WATER IMMEDIATELY FOLLOWING THE END OF EBB.

November 18, 10 *A. M.*—Ebb tide running about two knots:

Heading N. 21° 30′ W.	N. 21° 25′ W.	Mean N. 21° 29′ W.
21 40	21 20	

November 18.—Last of ebb. Hatch of captain's cabin lowered:

Old Pt. C. L. H.	Wh. Sh. L. Ho.	Old Pt. C. L. H.
N. 77° 40′ E.	N. 38° 00′ W.	N. 77° 20′ E.
77 30	37 50	77 30
77 20	37 00	78 20
79 20	37 30	78 20
78 20	38 00	78 00
78 10	38 00	78 20
78 00	38 10	78 10
77 40	38 20	77 40
N. 78 00 E.	N. 37 51 W.	N. 77 58 E.

Craney is'd.	R. R. tg.	Nansemond river, west shore tangent.
S. 33° 10′ E.	N. 86° 30′ E.	S. 49° 00′ W.
32 00	85 50	48 30
31 30	87 10	45 50
32 30	87 00	46 00
31 30	87 30	49 00
31 00	87 40	47 40
31 00	88 00	
29 30	88 00	
31 20	N. 87 12 E.	
30 10		
S. 31 22 E.		

November 19.—Last of ebb. Hatch lowered:

R. R. tg.	Old Pt. C. L. H.	Nansemond, tg.	Wh. S. L. H.
N. 86° 30′ E.	N. 78° 40′ E.	S. 48° 00′ W.	N. 39° 00′ W.
85 30	78 50	48 00	39 00
86 40	N. 78 45 E.	S. 48 00 W.	N. 39 00 W.
86 50			
87 10			
N. 86 32 E.			

Heading at 10*h*. 25*m*. N. 24° 20′ W.

Hatch raised:

R. Raps, tg.	Old Pt. C. L. H.	Nansemond.
N. 79° 20′ E.	N. 71° 30′ E.	S. 46° 30′ W.
79 20	71 10	42 30
N. 79 20 E.	N. 71 20 E.	42 40
		42 00
		S. 43 25 W.

White S. L. H.	Heading.
N. 43° 40′ W.	N. 27° 00 W.
45 00	27 20
45 50	27 20
N. 44 50 W.	28 20
	N. 27 30 W.

RESULTING ANGLES.

November 18.—Wh. S. L. H.—Old Pt. C. L. H.	115° 50′	w = 2	Mean 116° 24′
19 " "	117 45		
19 " "	116 10		
18 Old Pt. C. L. H.—R. R., tg.	9 13	w = 2	8° 33′
19 " "	7 47		
19 " "	8 00		
18 Nanse., tg.—Wh. S. L. H.	94 29	w = 2	Mean 93° 26′
19 " "	93 00		
19 " "	91 45		
18 Craney I.—Nanse., tg.			79 02

These angles place the vessel in latitude and longitude as given in the first appendix, true azimuth of line to Rip Raps from anchorage N. 75° 30′ E.

APPENDIX No. 3.

The following table of bearings is made up directly by interpolation from the general table of observations given in the body of the report, and contains the observed bearings of the line to the Rip Raps for each of the thirty-two points of the (disturbed) azimuth compass.

Heading by disturbed standard compass.	Rip Raps bear—	Heading by disturbed standard compass.	Rip Raps bear—
N.	N. 82° 50′ E.	S.	N. 71° 00 E.
N. by E.	83 52	S. by W.	67 03
NNE.	81 50	SSW.	63 57
NE. by N.	82 30	SW. by S.	62 44
NE.	81 08	SW.	61 51
NE. by E.	78 00	SW. by W.	61 35
ENE.	81 10	WSW.	61 46
E. by N.	86 34	W. by S.	64 20
E.	82 04	W.	67 56
E. by S.	86 34	W. by N.	70 00
ESE.	86 25	WNW.	72 02
SE. by E.	84 30	NW. by W.	76 55
SE.	83 30	NW.	82 00
SE. by S.	81 00	NW. by N.	83 55
SSE.	77 20	NNW.	85 24
S. by E.	73 37	N. by W.	85 06

Approximate correct magnetic bearing. Mean, N. 76° 35′ E.

APPENDIX No. 4.

Craney is'd bears S. 37° 00′ E. observed ∠ between R. R. and C. is'd.
" 36 30 N. 87° 12′ E. and S. 31° 22′ E.
" 32 00 61° 26′
" 31 50

APPENDIX No. 5.

Bearings by standard compass.

	Rip Raps.	Old Point C. L.	White Shoal light.	Nansemond.	Heading.
Hatch down..	N. 86° 30′ E.	N. 78° 40′ E.	N. 39° 00′ W.	S. 48° 00′ W.	N. 24° 20′ W.
	85 30	78 50	39 00	48 00	
	86 40				
	86 50	78 45	39 00	48 00	
	87 10				
	86 32				
Hatch up....	N. 79 20 E.	N. 71 30	N. 43 40 W.	S. 46 30 W.	N. 27 00 W.
	79 20	71 10	45 00	42 30	27 20
			45 50	42 40	27 20
	79 20	71 20			
			44 50	42 00	28 20
				43 25	27 30

Difference, deviation E, when up.. } + 7° 12′ + 7° 25′ + 5° 50′ + 4° 35′ + 3° 10′

Hence average deviation 5° 38′.

Appendix No. 6.

Record of simultaneous bearings November 19.—Ship's head.

By disturbed standard compass.	Correct bearing by standard compass.	By disturbed aft deck compass.	By disturbed tell-tale compass.	By disturbed middle turret compass.	By disturbed forward turret compass.
N. 27° 30′ W.	N. 31° W.	....	....	....	....
18 50	25	NW. ¼ N........	N. ¾ W........	NNW. ¼ N........	NW. by N. ¾ N...
N. 5 00 E.	6	NNW........	N. ½ E........	N. ½ W........	N. ½ W........
[N. 14 30 E.]	N. 3 E.	N. by W........	N. by E. ¾ E.....	N. ½ E........	N. ½ E........
22 30	11	N........	NNE. ½ E........	N. by E........	N. by E. ¼ E.....
49 00	33	NE. ¼ N........	NE. ½ E........	NE. ½ N........	NE........
67 00	50	NE. by E. ¾ E...	NE. by E. ¾ E....	NE. by E........	NE. by E. ¾ E....
*88 50	*71	E. ¾ N........	E. by N........	ENE. ¼ E........	E. ¾ N........
S. 68 00 E.	S. 87 E.	E. by S. ¾ S.....	E. by S. ¼ S......	E. ½ S........	E. by S. ¾ S......
49 00	64	SE. ½ E........	SE. by E. ¼ E ...	SE. by E. ¼ E. ..	SE. ¼ E........
22 00	29	SSE. ¼ E........	SE. by S........	SSE. ½ E........	S. by E. ¾ E......
10 40	12	S. ¾ E........	SSE. ¼ S........	S. by E........	S. ¾ E........
2 30	S. 3 W.	S. ¼ W........	S. by E........	S. 1° W........	S. ¼ W........

* The card was probably not quite steady. All the other compasses indicate a correction of about —4°. Hence the correct bearing, N. 67° E.

Appendix No. 7.

Bearing by disturbed compass.	Deviation of—					
	Aft deck compass.	Tell-tale compass with magnet.	Tell-tale compass without magnet.	Standard azimuth comp. Hatch down.	Middle turret compass.	For'ard turret compass.
N........	11° E.	12° W.	....	7° W.	1½° W.	3° W.
N. by E........	8	12	....	8	0	2
NNE........	1½	15½	....	6	1	5
NE. by N........	2½ W.	17	....	6	2½	8
NE........	5	18	....	4½	1½	10
NE. by E........	7	16	....	2	2½	12
ENE........	10	15	....	4	2½	14
E. by N........	14	15	....	5	2	15
E........	13	13	....	4½	1	15
E. by S........	13	11	....	9	1½	15
ESE........	15	8	....	9½	2½	16
SE. by E........	12½	5	....	7	3	15½
SE........	10	1½	....	5	1½	12½
SE. by S........	8	3 E.	....	3	1	11
SSE........	6	7	4° W.	0	1	9
S. by E........	6½	14	4	3 E.	2	4½
S........	5½	....	0	6½	3	3
S. by W........	0	....	3 E.	11	1	2 E.
SSW........	6 E.	....	8½	14	2	6
SW. by S........	12	....	13	15	3 E.	8½
SW........	17	....	14	15½	3	8½
SW. by W........	19	....	14	15½	3	11½
WSW........	20	....	14½	15½	4½	15
W. by S........	20	....	13	13	5½	13½
W........	22	....	9	9	3½	12
W. by N........	22	....	8	6	0	13
WNW........	20	....	4	4½	1 W.	10
NW. by W........	22	....	0	0	0	6
NW........	19	....	4	5½ W.	½ E.	2
NW. by N........	16	11 W.	....	7½	1 W.	1 W.
NNW........	14	14	....	9½	3 E.	2
N. by W........	11	15	....	9½	1½ W.	2½
N........	11	12	....	7	1½	3

Appendix No. 8.

Captain Gansevoort, in command of the Roanoke, requested me to examine the two compass arrangements above the turrets and report the result to the committee. I have to submit the following remarks: The reading of the com-

pass on the middle turret, by means of two reflectors, in clear weather and sunshine, is difficult for some time till the eye gets accustomed, but in cloudy weather the card can hardly be made out at all without artificial light. The two mirrors had been cleaned. To remedy this difficulty of reading I would propose the use of a binocular glass, magnifying about two or two and a half times, which may be fastened as in the arrangement proposed by me, (a sketch of which will shortly be submitted.) Using such a glass, I could read the compass with the greatest ease.

The forward turret compass (Ritchie's) had been changed since July last, the old one having broke from the concussion of the firing of the heavy guns. I was informed on board that the present fluid compass has stood, so far, the firing of the guns, but that it now leaks. If the leakage continues, the captain is afraid the compass may from this cause become useless.

Supposing the ship in action, and the turret compass taken down, (or otherwise disabled,) the ship can be steered by means of the cabin compass, for which purpose a speaking-tube should extend from the cabin to where the helmsman is stationed; this I consider a simple and effective arrangement.

S.

STEERING DYGOGRAM FOR FORWARD TURRET COMPASS.

To steer SE., correct magnetic, (for example,) bring the fore and aft line in the direction of the tangent to the SE. cusp; a parallel line through the centre gives the corresponding (magnetic) compass course SE. by S., and consequently the deviation 11° W.

APPENDIX No. 8.

Description of Riichie's monitor compass.

The distinctive principles of this compass are, first, the separation of the magnet from the card or index, so that the magnet may be elevated above the sphere of disturbing attraction of the iron of the ship, while the card is brought to a convenient position to be seen by the pilot; and second, the suspension of the movable portion in a liquid so as to attain entire freedom from friction, that the needle may obey the polar force, and at the same time to secure great steadiness in the card.

The accompanying drawings give plan, elevation, and sections, and also, in detail, every principal part of the compass drawn to scale, except the length, which must vary according to the circumstances in which it may be placed. In ships of the monitor plan it has been found sufficient to make the outer tube of eight feet in length, (see figs. 1 and 2.)

Fig. 1, is a front elevation of the pilot-house with compass attached, as seen from the head of the vessel.

Fig. 2, section of the same, cut in a line fore and aft the vessel, and north and south of the needle and card.

Fig. 3, elevation enlarged; the position the same as in fig. 2.

Fig. 4, section cut in same line as figs. 2 and 3.

Fig. 5, transverse section of upper portion, cut east and west, and elevation of lower portion as seen from aft.

The principal parts are a globe, (see figs. 3, 4, and 5,) containing an interior globe, (see figs. 6 and 7,) open at the top and under side for a circle of about 22°; this globe is held by a gimbal ring, allowing a free motion of 20°.

The object of this inner globe is to prevent a circular motion being given to the liquid under certain motions of the ship, by friction of the outer vessel upon the surface of the water contained.

Within these globes is placed the magnetic needle, enclosed in cylindrical air vessels, (see fig. 4,) and secured by a gimbal to a shaft, (see fig. 8,) which passes down through a tube to an enlarged chamber of glass, within which, and attached to the same axis, are the cards or dials, (see figs. 4 and 5,) one or more, upon which the compass points are painted, by which the direction of the magnetic needle is known. In this construction the needle and its enclosing air vessel, the axis, (itself a hollow tube,) and the card or cards, with its supporting air vessel, (see figs. 4 and 10,) are, as nearly as possible, in the whole and in the separate parts, of the same specific gravity as the liquid in which they are immersed. All tendency to flexure of the axis, either by inclination or by any impulse or blow given to the outer tube, is thus prevented.

The pivots connecting the air vessel or float, as also the journals of the axis, (see fig. 9,) serve to keep the parts in place, but do not support any weight; consequently *friction* is almost annihilated.

The card may be made to read from either side. When it is intended for the pilot to stand abaft the compass, as he does inside the pilot-house, the north point on the card is placed under the south end of the needle; the "*lubber line*" is placed on the side of the card nearest to the observer, (instead of being on the opposite side,) and gives the direction in which the ship is *heading*, but the order of the compass points being preserved, no inconvenience or confusion has arisen from this. When the pilot stands before the compass, as at the outside wheel, the north side of the card and north of needle coincide, the lubber line, as before, giving the heading of the ship.

The liquid used is alcohol and water of the specific gravity of 33° centigrade hydrometer, or two-thirds pure water and one-third absolute alcohol.

Placed above the large globe is a smaller one, (see figs. 3, 4, and 5,) with a rubber diaphragm. The lower half is filled with liquid. This appendage is intended to allow for the unequal expansion of the liquid and the brass. As the temperature increases, a portion of the liquid is forced into the globe; or, as the temperature decreases, a portion of the liquid from the upper globe is carried down. The elastic rubber diaphragm prevents the evaporation or spilling of the liquid.

The globe (*a*, fig. 4) of Prince's metal, of 8 inches diameter and 0.1 inch thickness, is divided into two equal parts, which are fastened together by screws, a thin washer of leather being placed between to prevent leakage.

The lower half is attached by a screw-thread and soldered to the tube (*b*,) and by a stout flange, is attached to the tube (*c*) by means of screws.

The other half supports a globe (*d*.) Concentric, and nearly in contact with the upper half, is a strong bail, 1.1 inch wide and 0.1 inch thick, fastened to the lower half by screws; to this bail is attached a rod (*i*) which supports the axis.

Within the globe, and supported by journals, is a gimbal ring, 7.95 inches in diameter outside, 0.1 inch in thickness, and 1 inch wide.

The interior globe, (*e*,) 7½ inches diameter, .04 inch thick, is made in two halves, joined by a ring inside of ½ inch width, soldered to the lower half, and fastened to the upper half by small screws. Two journals attach this globe to the gimbal ring. There is an opening in the upper half, 3 inches diameter, and a similar opening in the lower half, 3¼ inches diameter. The globe has a free motion in every direction, until the edge strikes the rod (*i*;) a leaden weight (*g*) is soldered to the lower half of the globe for ballast.

A rod (*i*) screws into the bail and is held tightly in place by a binding nut; in the lower end is inserted a double jewel, (as shown in detail, see fig. 9.) an agate ring, drilled .08 inch diameter, which allows the point upon the top end of the axis to pass through and touch upon another plane agate.

The globe (*d*,) 4½ inches diameter, is made in two equal parts, joined by screws; between the halves is fastened a sheet of vulcanized rubber .15 inch thick.

The needle air-chamber, or float, (*h*,) is made of thin brass, and is a cylinder of 1½ inch diameter, with hemispherical heads, 6¾ inches entire length; at right angles from the middle extend two similar cylinders, which assist the buoyancy and equalize the resistance of the liquid.

An elliptical hole is made through the larger tube 1.4 inch in length, and 1 inch in width; a ring of thin metal passes through, and the whole is soldered air-tight; every part is tinned.

The needles are made of six plates of steel, filling the section of the float from either end to near the central opening, where they are bent and narrowed as shown in the drawings, and pass around in the space between the cylinder and the interior ellipsoid. The plates are riveted together by copper rivets; their extremities for 2½ inches are hardened.

Within the ellipsoid is placed a gimbal ring and bar to attach the needle float to the axis, (see fig. 8;) the bearings made of low bell-metal, resting in agate centres.

The weights of the several parts are as follows:

Weight of double cylindrical air-vessel, with interior ellipse, (expressed in grains)	1, 300
Weight of each needle 300 grains, 6	1, 800
Weight of gimbal ring and bar, complete	140
Weight of lead ballast	200
Weight of liquid displaced	3, 440

The axis for 6¼ inches is made of brass wire of 0.14 inch diameter, which

is there joined to a brass tube of 0.6 inch diameter, and of such thickness that its weight, including the wire, is equal to the same volume of the liquid.

The lower end, where it joins the enlarged tube or card air-vessel, is closed and balanced so that neither side will preponderate. To effect this the tube is very accurately drawn on a steel mandrel, and carefully adjusted in a trough filled with the liquid.

The cards are made of thin brass, the top and exterior of one piece; the bottom is cut to the form of a ring, with four arms, and is soldered to the lower edge of the card, and joined by a thin tube to the upper plate; the central tube or air-chamber is of thin brass, drawn on a steel mandrel 0.85 inch diameter and 12.75 inches length. The upper end is closed by a thin head formed with a socket to fit the axis. The lower end is also closed by a head with a pivot or journal fitted to agate bearings, similar to those in the rod *(i.)* This tube, with the cards, having the compass points pointed upon them, is also accurately adjusted. This adjustment is effected by small pieces of lead wire attached to the arms of the cards. Not only are the portions of the axis and card air-vessel thus separately balanced, but the whole is adjusted to the same specific gravity as the liquid, so that neither side nor end shall preponderate when immersed in a horizontal position.

A longitudinal play of 0.1 inch is allowed the axis.

The large globe is attached to a tube of $4\frac{15}{16}$ inches exterior diameter and $\frac{1}{16}$ inch thickness of hard-rolled and hammered brass, which forms the frame or support of the compass, and is also attached by a screw, and soldered to an inner tube of $1\frac{1}{2}$ inch diameter and $\frac{1}{16}$ inch thick, through which the axis passes to the chamber below, which contains the card or cards.

The lower end of the inner tube is screwed and soldered to a head of brass fitting the interior of the outer tube, and is firmly held in place by screws. Two glass cylinders of 4 inches interior and $4\frac{3}{4}$ inches exterior diameter, each of 6.3 inches length, separated by a ring of brass of 1 inch length are placed beneath. A head of brass closes the lower glass cylinder and supports the lower end of the axis.

A flanged ring is placed below the lower head, firmly held in position by screws inserted from the outside cylinder, and furnished with screws, which compress the glass cylinders between the heads; washers of thin leather saturated with wax and rosin being placed in all the joints.

A band of thick white paper is placed between the glass and the outer tube, to reflect light upon the lower card.

Openings or windows are made in the outer tube, of 4 inches length by 3 inches width, through which the cards are visible, and two smaller windows are made to admit light to the lower card.

A head of brass closes the lower end, pierced with holes opposite the screws in the flanged ring for convenience in lightening them if necessary. Two small wires—one attached to the dividing ring between the glass cylinders, the other to the bottom plate—are placed just within the glass for the "*lubber lines.*"

An arm extends from the lower plate to support the lantern, which is furnished with a lens for concentrating the light upon the card.

The compass is supported by a ring secured to the tube, which rests in another ring let into the top iron plate of the pilot-house; a "*feather*" secures the "*lubber lines*" in their position in the fore-and-aft line of the ship.

A strong brass ring elevated 3 feet above the deck and sustained by 3 stout copper legs serves to hold the compass, and also the awning cloth.

This ring opens on one side so that the compass may be readily removed without disturbing the larger portion of the ring, to which the legs are attached.

A second lantern is attached to the deck of the pilot-house, to light the upper card.

APPENDIX No. 9.

Plan for mounting of compass on board turreted iron vessels, proposed by Chas. A. Schott, United States Coast Survey.

The compass is placed in the upper end of a tube projecting over the centre of the steering turret, and is read by means of a small glass and a reflector.

The general disposition is shown by the figures drawn to scale of real size, $\frac{1}{16}$, $\frac{1}{24}$ in photograph.

A, is a round copper tube, secured by means of screws to the top of the turret, and provided with two flanges to give easier access to the top, which is square, and contains a tell-tale compass with transparent card. This compass should be steadied, so as to have as little swinging motion as practicable. Light is admitted from the top and two sides (opposite one another.) These window panes are marked BB. At night two lanterns, CC, with lenses, illuminate the face of the compass, which is reflected by a plane mirror, D, and seen through the binocular glass E, conveniently placed for the man at the wheel. This small telescope magnifies between 2 and $2\frac{1}{2}$ times, for a height of table of 8 feet. By turning the reflector a little the compass may be seen, keeping the eye a little above or below the telescope, as there is hardly a necessity for using it constantly. If the tube is but 6 feet long, the opera glass need magnify but twice.

The head of the tube is shown separately on the scale of real size, $\frac{1}{4}$, $\frac{1}{6}$ in photograph.

a a, top and side windows.

b, compass card and needle inside top and bottom glass case, the whole suspended in gimbals *c c*.

d d, lanterns with lenses—plane outside, convex inside.

When the lanterns are removed for trimming and filling, the small circular hole *e*, opposite the lens, is seen.

When the ship is in action the tube, the telescope, and mirror can readily be removed, and the aperture in the turret closed; there is no need of exposing the compass unnecessarily, as the steering can be done by means of a compass *below deck*, with a communication by a small speaking tube leading from the place of the compass to the inside of the steering turret.

Respectfully submitted, by

CHAS. A. SCHOTT.

DECEMBER 27, 1863.

Admiral C. H. DAVIS,
United States Navy, Bureau of Navigation.

G.

The committee appointed to report upon the new form of alcoholometer prepared by Joseph Saxton, esq., reports: That the instrument consists of a glass bulb of spheroidal form, to which is attached a chain of one hundred links, which are smaller in proportion as they are nearer to the lower end of the chain. For the sake of convenience in reading, each tenth link is of a different form from the others. The instrument is so graduated that in pure water, at the normal temperature of 60° Fahrenheit, it floats entirely immersed and carrying suspended its whole chain; whilst in absolute alcohol at the same temperature the bulb alone floats, the whole chain lying on the bottom of the vessel. Each link of the chain is made of such weight that the number lying on the bottom,

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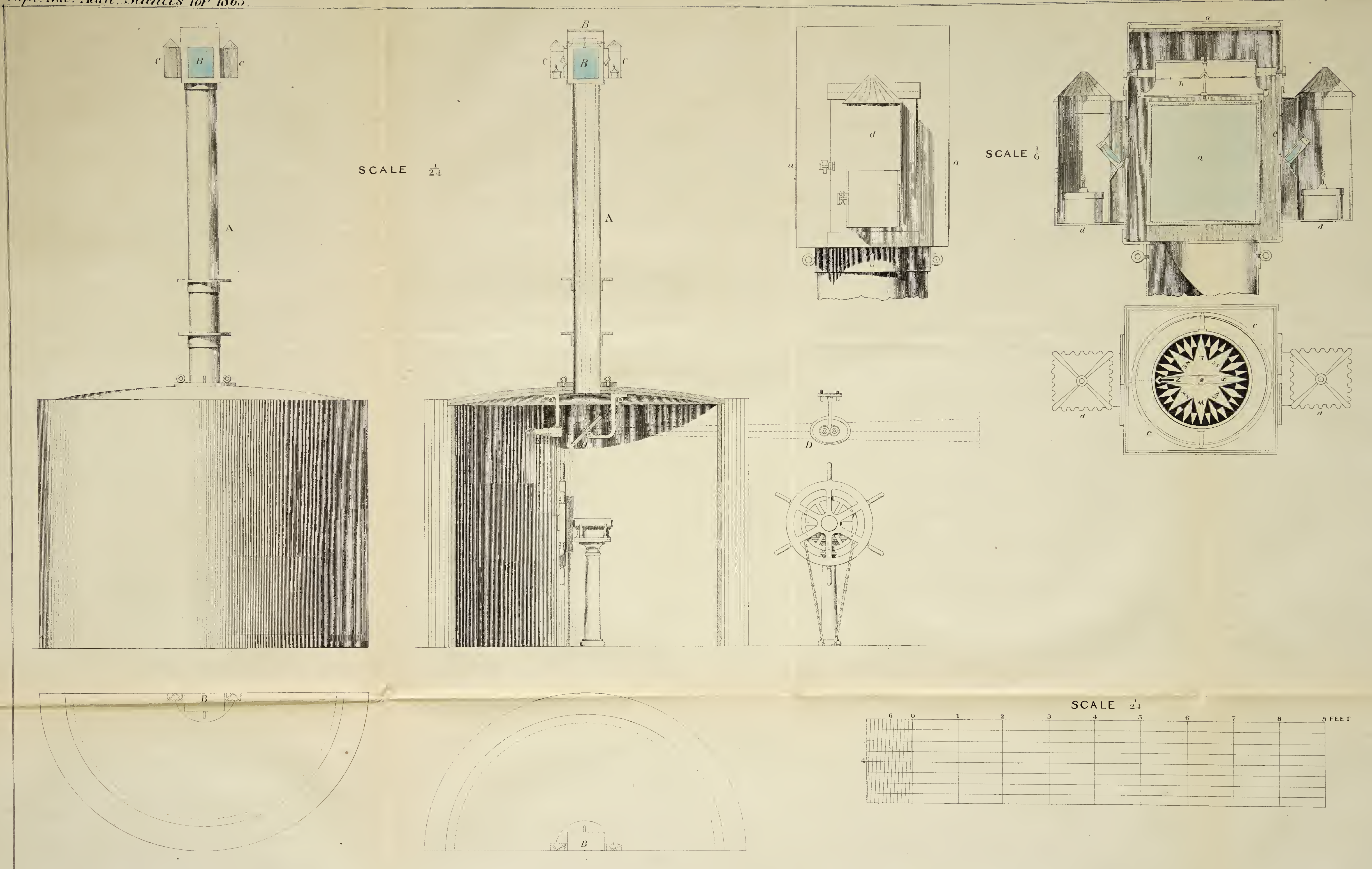

Lith. of Bowen & Co. Philada.

in any given mixture of alcohol and water at the normal temperature, represents the percentage of alcohol in that mixture. Should the liquor be at any other temperature, the ordinary tables will suffice for the reduction of the apparent to the true strength.

The instrument thus constructed appears to the committee to be preferable for common use to that of Tralles on the following points:

1st. It is much more portable, occupying less space and being less liable to be broken during transportation or use.

2d. Its scale is much more easily read, the number of links deposited being easily counted under any supposed circumstances; whilst in many cases it is extremely difficult to determine the exact line of contact of a colorless liquid with a white stem, and to make the proper allowance for capillarity.

On the other hand it will require much care in its construction, the graduation of the links requiring peculiar attention. For ordinary use the change of weight at each tenth link (which appears to have been the graduation adopted in the model submitted to the committee) will doubtless be a sufficient approximation to the truth; but if, as Mr. Saxton suggests, an attempt be made to get a more delicate graduation, by the use of aluminum as the material for the chain, then a corresponding nicety must be used in the graduation to make the scale accord with the varying differences of density in different mixtures of alcohol and water. To do this will be a work of great labor, and one requiring a very skilful workman. The government will therefore probably be compelled to make its own instruments. Care must also be taken, in using the instruments, to remove all the air, which will adhere to the links of the chain, especially to the finer ones; a neglect of this precaution will produce quite a perceptible error in the estimate of the density. The instrument will, therefore, be reliable only in careful hands.

The committee are of opinion that, upon the whole, the advantages of the newly proposed form far overbalance the objections to it, and therefore recommend its use by the government in place of the alcoholometer now used, it being understood that Mr. Saxton places this invention at the disposal of the government without any view to remuneration.

JOHN F. FRAZER.
JOSEPH G. TOTTEN.
F. A. P. BARNARD.
WILLIAM CHAUVENET.

A. D. BACHE, LL.D.,
President National Academy of Sciences.

H.

WASHINGTON, *January* 7, 1864.

DEAR SIR: In taking out a patent for the hydrometer I do not intend to interfere with its free use by the government. My object in patenting it is to have control of its manufacture in private establishments only.

Very respectfully, your obedient servant,

JOSEPH SAXTON.

Professor A. D. BACHE, LL.D.,
President National Academy of Sciences.

I.

Report of the committee of the National Academy of Sciences appointed to examine the "Wind and Current Charts" and "Sailing Directions" issued from the Naval Observatory.

In the month of May, 1863, a letter was addressed, on behalf of the Secretary of the Navy of the United States, to the president of the National Academy of Sciences, requesting him to submit to the academy for examination and report the question of the expediency of discontinuing the publication in their present form of the "Wind and Current Charts" and "Sailing Directions" heretofore issued to navigators from the Naval Observatory. In consequence of this request the undersigned were appointed by the president of the academy a committee to make the proposed inquiry. Having signified their acceptance of their appointment, they were severally furnished with copies of the publications referred to; and, after a careful examination of the subject and an interchange of views, they have agreed upon the following report:

The publications submitted to the committee consist of seventy-six charts of large dimensions, measuring generally twenty-four inches by thirty-five or six within the borders, and classified into six distinct series, distinguished by the letters A to F. These classes are entitled severally, "Track Charts," "Trade Wind Charts," "Pilot Charts," "Thermal Charts," "Storm and Rain Charts," and "Whale Charts." Besides these there are two thick quarto volumes of letter press, embracing pp. XXXXI, 383, and VIII, 874, respectively. The first of these volumes is illustrated by sixty-three engraved plates, some of them colored, and the second by six. Supplementary to these are three thin tracts, also in quarto, entitled "Nautical Monographs," and embracing in all pp. 48 and five plates.

The plan of the publication appears not as yet to have been fully completed. According to the programme laid down in volume II, pages 873-4 of the "Sailing Directions," the total number of charts contemplated was originally one hundred and twenty. It appears, however, from the numbers upon the margins of some of the sheets, that this programme had been subsequently enlarged, two of the charts bearing the numbers 125 and 129, respectively. As observed already, seventy-six only have yet appeared. The motive for the publication, as stated by the principal compiler, was, that "by putting down the tracks of many vessels upon the same voyage, but at different times, in different years, and during all seasons, and by projecting along each track the winds and currents daily encountered, navigators hereafter might have for their guide the results of the combined experience of all whose tracks were thus pointed out," and that thus "the young shipmaster with these charts before him might be immediately lifted up and placed on a footing with the oldest sea captains in this respect." From this statement it would appear that the original design of the work was simple, and was of a nature purely practical. In its prosecution, however, the compiler seems to have been tempted to extend his labors into higher and more varied fields. Hence it arises that many matters which have no necessary connexion with navigation, such as the Atlantic telegraph, marine zoology, including microscopic life in the ocean, deep-sea soundings, and the form of the ocean's bed, the specific gravity of sea-water in different latitudes, ocean climatology, and the like, are treated here with a fulness and a seriousness hardly less than are bestowed upon the more direct objects of the work, and such as to show that the writer has only ceased to pursue them from the exhaustion of his material. The aspect, therefore, which these volumes exhibit, more especially the first of them, is that of a collection of essays upon matters of science and natural history, thrown together, indeed,

rather loosely and disjointedly, but by the aid of fair topography, copious illustrations, and a lively and generally felicitous style, prepossessing the reader very much in their favor, and in fact producing a first impression not a little imposing.

The wide circulation, also, which these publications have received, has contributed to give them a kind of adventitious repute, which productions of greater substantial value without these advantages might have failed to secure.

It is stated in the introduction to the eighth edition of the "Sailing Directions," which is the edition laid before the committee, that up to the year 1858 more than two hundred thousand sheets of the "Wind and Current Charts" had been distributed, and more than twenty thousand copies of the "Sailing Directions." Thus the compiler has become very widely known; and in most quarters in which he is known his works appear to be regarded as partaking as much of the nature of scientific investigations as of practical aids to navigation.

In the prosecution of the examination and inquiry referred to them, the committee therefore have been somewhat embarrassed by this double aspect presented by the works laid before them. It has seemed impossible to arrive at a just appreciation of the merit of these works without examining them from two points of view entirely distinct, directing attention first to their scientific, and secondly to their practical value.

It is under the second aspect, however, that the subject appears to be regarded by the department by which the inquiry is submitted, and it is with this that the committee has been principally occupied. It has, nevertheless, appeared impossible to avoid some notice of the claims of these publications considered in their properly scientific character; although this notice is condensed within the narrowest limits that justice to the subject will allow. It is, perhaps, expedient to dispose of this in the outset.

When we examine these works with a view to estimate their value to the interests of science, we presently perceive the necessity of distinguishing between the contributions which they contain to our knowledge of the meteorology and general physics of the globe, and the interpretations which have been put upon these data and the theories deduced from them by the compiler. The contributions themselves consist principally of observations of the directions of the winds, the temperature of the waters, and the frequency of occurrence of lightning, thunder, storm, and rain, over a large part of the open ocean; the observations being numerous in different regions, in proportion as each is more or less frequented by navigators. These observations are valuable as assisting in the study of the great system of atmospheric circulation and of the influences which modify climates. The plan according to which they have been digested is also, perhaps, as good as the circumstances of the case will allow. Fixed observatories upon the ocean being impossible, no continuous series of observations upon the winds of any given locality can be carried out. The only method which seems to be practicable of overcoming this difficulty, is to collect the scattered observations of navigators and to group them according to certain areas of determinate limits, and according to the seasons or months within which they were made. Such is the plan which has been pursued in the preparation of these charts. The ocean has been divided into limited areas by meridians and parallels of latitude drawn, usually, five degrees apart; and any observation upon the direction of the wind at any given time, within any one of these areas, has been assumed to represent the wind prevailing at that time over the entire area. The direction in which the wind is observed to blow most frequently in any month is presumed to be that of the predominant atmospheric current; and the relative tendency to blow in any direction is supposed to be measured by the ratio of the number of observed winds in that direction to the total number of observations.

The results obtained by this method of analysis and classification will be deserving of confidence in proportion as the total number of observations is greater. For the more frequented parts of the ocean there have already been embodied in these charts a sufficient number to render the manifestation of law very decisive. From other parts the contributions are few, and in some they fail altogether. This inequality, however, must always continue to exist, even though all navigators of all nations should engage in the work of observing, and though all the observations thus gathered should be poured into the common stock, since there are and always will be vast tracts of ocean which present scarcely any attraction except to the professed explorer.

The value of these charts, so far as the winds are concerned, would have been materially greater than it is had the element of force been considered as well as that of direction. As the work is now presented, equal weight is allowed to every observation, and a light breeze counts for as much as a violent gale. It is possible that this defect is not the fault of the compiler, but the necessary consequence of the loose and imperfect manner in which records were kept in the original logs.

At the maritime conference held in Brussels in 1853, having in view the creation of a universally comprehensive system of meteorological observation by sea and land, a form of record for each class of observations was adopted designed to secure attention to every important particular; and in this form wind-force occupies, as it should do, a conspicuous place. In November of the same year the recommendations of the Brussels Conference were approved by the Secretary of the Navy of the United States, and the form of Abstract Log proposed by the conference was directed to be faithfully kept in all the vessels in the public service of this government.

It appears, from the dates quoted in various parts of volume II of the "Sailing Directions," that the logs which have been examined in the preparation of these works come down to the close of the year 1857. During the four years preceding the date last named, therefore, the logs of the public armed vessels of the United States must have furnished data for a more satisfactory discussion of the winds than these charts present. The same is, doubtless, also true of the logs relating to the same period contributed by merchant vessels. It is evident, therefore, that the publications before the committee exhibit but imperfectly the information which they profess to embody, and which was actually in the hands of the compiler.

It may be further remarked that, in the digestion of the material relating to the winds which is furnished by the logs, an assumption is constantly made which tends to impair confidence in the conclusions arrived at. The observations having been made at regular intervals of eight hours each, every observation is presumed to represent a wind steadily prevailing during the entire period of eight hours. That such a principle must lead to very uncertain results when the number of observations is limited, is very evident. But, furthermore, that it must often occasion perplexity to the observer who desires conscientiously to discharge his duty, is manifest from the inquiries addressed to Lieutenant Maury on this subject by an officer of the French navy, and given at page 344, volume I, of the Sailing Directions. These questions, with the answers of Lieutenant Maury, are as follows:

"Must I always enter the observations of calm, or only when the calm has been prevalent during the eight hours?"

"Ans. Enter it only when the calm has been the most prevalent condition for the eight hours."

"I have had one hour of calm, six of north wind, and another hour of calm; what must I enter?"

"Ans. North wind."

"I have had one hour of north wind, six of calm, and one hour of westerly wind; what shall I note?"

"Ans. Calm."

"I have had four hours of N.NW. wind and four hours of S.SW.; must I enter both, or the resultant—eight hours from the west?"

"Ans. Enter as eight hours from the west, and call attention to it in your remarks."

"What must I put down for four hours of north wind and four hours of south wind?"

"Ans. Enter the wind as prevailing from the point from which, in the case supposed, it has been strongest; but note in the column of remarks," &c., &c.

These interrogatories serve to illustrate the uncertainty which must always, more or less, affect the results of observations made and digested according to the plan adopted in these publications, and show how much more valuable would be a system of record which should give not only the direction and force, but also the duration of each wind observed.

The absence of any record of duration still more seriously impairs the value of the observations on storm, rain, thunder, lightning, and fog. These phenomena being of irregular occurrence, and in their nature comparatively transient and often of limited extent, the supposition which spreads them, in each instance, over a period of eight hours and over a surface more or less of 70,000 square miles, must lead to very erroneous deductions in regard to their frequency at any particular locality.

The facts presented in what are called "Thermal Charts," in regard to the surface temperature of the ocean in different seas and at different seasons, are interesting in connexion with the study of ocean currents and the science of climatology; but this interest is considerably diminished by the circumstance that all the observations are given precisely as they are entered in the logs, without any correction for error of thermometer.

The student of natural history will find something to interest him in the charts which exhibit the range of the sperm and right whale. He will probably be disappointed on examining the numerous showy illustrations of microscopic life in the ocean, with which the first volume of the Sailing Directions is embellished. These, beautiful as they appear, embrace little if anything that is new; and that little is not presented in an available form. In the words of Professor Dana, a member of this committee, by whom they were examined before their publication, and whose letter on the subject to Lieutenant Maury is quoted on page 220, volume I, of the Sailing Directions, "they lack just that exactness which is necessary to render them available to science. They are not sufficiently detailed to determine the genus in all cases, much less the species."

The plan of meteorological observation recommended by the Brussels conference was well conceived, and, when the very numerous records which have been kept by the navigators of the co-operating nations shall have been analyzed and digested, will doubtless serve to throw much light upon the laws which govern the phenomena of the atmosphere and the ocean. But the publications before the committee embody but a limited portion of the material which it was the design of that plan to collect. The volumes contain little and the charts nothing at all in regard to the temperature, pressure, or hygrometric state of the air, to the force of the winds, to the form or prevalence of clouds, to terrestrial magnetism, to the temperature of the ocean depths, or to such interesting occasional phenomena as shooting stars, haloes, and aurora borealis.

Since the approval of this plan by the Secretary of the Navy of the United States there have been received at the observatory more than nine thousand abstract logs from merchant vessels and the naval service; and of these nearly six thousand had been received before the publication of the eighth and last

edition of the Sailing Directions. The scientific interest of that portion of the material embraced in these logs, which does not appear in the present publication, and for which no place has been provided in it, is certainly not less than that which attaches to the portion which is given, and in some particulars is even greater. It may, however, be doubted whether any special advantage to science would have been gained by spreading this suppressed material, as might easily have been done, over the surface of half a dozen additional series of charts. For every useful purpose it might have been, or might be, condensed into a tabular form, much more convenient for consultation than that which the surface of a large chart, or of a number of large charts, presents. And this remark, indeed, may be extended as well to most of the matter of the present publication.

If we pass now to consider the theoretical speculations and discussions which fill the greater part of the first volume of the Sailing Directions, we shall find upon nearly every page propositions to which we are not prepared to yield an unquestioning assent. It would be profitless, as well as apart from the design of the present inquiry, to examine these propositions in detail. A few examples will suffice to illustrate their character.

As one of these examples we may select the law laid down as governing the general circulation of the atmosphere. It is assumed in this work that the great trade-wind surface currents, when they meet at or near the equator, cross each other without interference; so that each, in rising to the upper region of the atmosphere, continues to pursue its course with only such change of direction as is consequent upon the earth's rotation. The superior current of the northern tropical region consists, therefore, of the same identical air which formed just before the inferior current of the southern tropic, and *vice versa*. A similar crossing of currents is further assumed to take place at the limit of the trades in each hemisphere; the upper current descending and the lower current rising without a permanent mingling or interruption of each other's progress. If, in this account of the movements of the atmosphere, it were designed to say that there are currents moving as currents *would* move were they thus successively to cross each other, though we might not be prepared to accept the theory as a whole, we should nevertheless not be disposed to visit it with severe criticism; but when it is made the essential part of the theory that the intersecting currents shall preserve their identity, we are compelled to submit that it assumes a physical impossibility.

Intimately connected with this view of atmospheric circulation, and dependent on it, is the theory put forth in these volumes in regard to the sources of the natural irrigation of the lands of the two hemispheres. North America is supplied with rain from the North Pacific ocean; northern Europe and Asia from the South Atlantic; the tropics are the evaporating regions; the extra tropical portions of the earth, the precipitating regions. The trade wind of the southern hemisphere sucks up a vast amount of moisture, which it carries without material loss through the upper regions of the air over the northern trade wind; and then, descending as a southwest surface wind, precipitates upon the continents of the north. By a similar process the trade wind of the northern hemisphere supplies the more limited continental areas of the south.

It is argued that this fanciful hypothesis must necessarily be true, on the ground that the evaporation of the southern hemisphere is greater than that of the northern, and the amount of its precipitation less. Objectors may possibly be found to assert that these grounds are not established; that if the southern hemisphere has a greater surface of water than the northern, it has also a lower temperature; and that if the rivers of Australia and South Africa are not large, those of South America are the largest in the world. Such may also desire to be referred to authorities when they are informed, as on page 22, volume I, that "meteorologists tell us the amount of rain which falls in the north temperate

zone is half as much again as that of the south temperate." For the amount of rain which falls upon the open ocean there are no data on which to found a comparison. For the amount which falls on land the data are insufficient for so remarkable a generalization. Nor do all the illustrations introduced by the writer, in the discussion of this subject, very strikingly conspire to support the foregoing conclusion. Comparing, for instance, the amount of downfall upon the similarly situated rain-precipitating coasts of Patagonia and Oregon, he says of the former: "Captain King found the astonishing fall of water here of nearly thirteen feet (one hundred and fifty-one inches) in forty-one days; and Mr. Darwin reports that the sea-water along this part of the South American coast is sometimes quite fresh from the vast quantity of rain that falls." For the corresponding northern latitude he gives the quantity of rain which fell at Oregon City in the month of January, (the rainy season,) in 1851, to be $13\frac{63}{100}$ inches. Reduce these figures to a common period, and the south has the advantage over the north in a ratio of more than eight to one.

It is another proposition, laid down and enforced with much reiteration, that the water which falls upon the surface of the earth, in whatever latitude, is entirely, or almost entirely, raised from the torrid zone. This, indeed, is a necessary corollary from the doctrine of atmospheric circulation explained above; for, according to that doctrine, the surface currents of the trade-wind regions are supplied with air exclusively from the upper atmospheric strata of the higher latitude; which strata have been thoroughly exhausted of their moisture by the rigor of the polar cold. These trade-wind currents are thus prepared to lick up greedily the waters of the tropical ocean. They become highly charged with moisture, which they afterwards deposit when they form a second time the surface currents of the regions beyond the limits of the trades, in the opposite hemisphere. As their movements are thenceforward from warmer to colder latitudes, their precipitation must be constant, and their evaporating power next to nothing. Upon the hypothesis just stated, a computation is made of the amount of surface evaporation in the torrid zone, which is necessary to supply the precipitation of the entire globe. Taking the mean annual downfall of the earth's entire surface to be five feet, and assuming the area of the evaporating zone to be three thousand miles by twenty-five thousand, the mean annual evaporation upon this zone is calculated to amount to sixteen feet. The data give but thirteen; but this, perhaps, is unimportant, since the result is said by the writer to be confirmed by direct observations, for which authorities are cited, in the Indian ocean. Apparently, however, the writer, in some of his discussions, fails to bear in mind what he has proved in others. Upon page 294, vol. I, his thoughts are directed toward the vast amount of solar force concerned in raising the waters which subsequently fall upon the earth in the form of rain; and here he draws his illustration from the valley of the Mississippi. This valley, according to his theory just above stated, lies in the region in which the amount of evaporation is insignificant, or zero; but, for the purpose immediately at hand, he makes the evaporation to be six-sevenths of the downfall. Between the same isotherms, in the same hemisphere, the average evaporation cannot be less than this, unless within the limited areas of regions nearly rainless. In the Atlantic ocean, the high temperature of the vast surface affected by the Gulf Stream must render it considerably greater. Two-thirds, at least, then, of the temperate zone supply, in great part or entirely, their own precipitation, and this is according to the statements of the writer himself. Making allowance for this circumstance, and supposing no evaporation at all to take place above the mean latitude of 50°, the amount of evaporation from the region of the tropics, calculated according to the method of the writer, would but slightly exceed eight feet per annum; and of this, at least three-quarters would be required to supply the precipitation of the evaporating zone itself.

But if these views of the laws of atmospheric circulation appear unsatisfactory

to the philosopher, they seem to have found equally little favor with observant navigators. An illustration of this may be found in the "Comptes Rendus" of the Academy of Science of France, for the 23d March, 1863. We find here a notice by M. Duperrey of a memoir by M. Bourgois, commander of the French ship Le Duperré, on a voyage to China in 1860; and subsequently of the frigate La Forte, on a return voyage to Europe in 1862; "during which period the author devoted himself to the careful observation of facts in hydrography, meteorology, and the general physics of the globe." Of this memoir M. Duperrey speaks as follows: "Among the number of these numerous and beautiful observations, those which relate to the laws governing the winds and currents are of high interest in this respect; that having been made with an attention unremitting, scrupulous, and independent of any preconceived idea, they allow us, in view of the unalterable truths which the author has deduced from them, to distinguish among the different systems, more or less hypothetical, proposed up to the present time, those which deserve attention from those which have the great disadvantage *(inconvenient)* of leading navigators and physicists into error."

The following are some of the conclusions of this memoir, as cited by M. Duperrey. M. Bourgois says: "I have taken account, with perhaps too scrupulous fidelity, of the observations of winds made on the route from Europe to China and from China to Europe, on board the public vessels which I have successively commanded, or of which the logs *(journaux)* have fallen into my hands. The reader can see, disclosing itself at each step, a complete disagreement between the facts observed and the hypothesis admitted by Mr. Maury, (of the United States,) in his system of the winds; and, on the contrary, a frequent verification of the general facts established by Mr. Lartigue upon the circulation of the atmosphere at the surface of the globe. The observations given in the present memoir would be assuredly too few, in comparison with those set down by the author of the 'Physical Geography of the Sea,' to invalidate the conclusions drawn from these last, if they contradicted mine. But this author does not seem to have had recourse, in writing his book, to the vast compilation of facts with which his laborious efforts have enriched meteorology; he has allowed himself rather to be guided by his lively and fertile imagination, and has owed the success of his work much less to the exactness of his hypothesis, and to the rigor of his deductions, than to the bold originality of his conceptions, and the captivating charm of his style.

"Neither the system of winds of Mr. Maury, nor any other which it might be proposed to substitute for it, could, nevertheless, have a more solid basis than the intelligent interpretation of the innumerable wind observations inscribed upon his own charts. It is by the aid of these observations that Mr. Maury ought to have been able to furnish his readers with proofs of the existence of the continuous zones of equatorial and tropical calms which form the basis of his system. The dryness of this kind of proof might perhaps have injured the popularity of his book by repelling superficial readers, but science and truth would have found their account in it.

"Perhaps, also, Mr. Maury himself would have shrunk from the random hypothesis which he has ventured to introduce into his 'Physical Geography of the Sea,' while thus neglecting the instructions furnished by facts of observation collected by himself.

"Mr. Lartigue, in the '*Nouvelles Annales Maritimes de* 1860,' had already given numerous proofs of the disagreement between these facts and Mr. Maury's theory of the winds.

"This disagreement is not less than that between the same theory and the observations of the winds collected on board the ship Le Duperré, the frigate La Forte, and other vessels of the expedition to China, such as L'Andromaque, La Vengeance, Le Rhin, L'Entreprenante, and Le Rhone."

The foregoing opinion is cited because it is recent, and because of the high

responsibility of its source. If others were desired, it would not probably be necessary to seek far to find them.

In treating of the subject of ocean currents the compiler of the works before the committee has attributed an exaggerated importance to the supposed excess of tropical evaporation assumed in his theory, and its effect in disturbing the equilibrium of the sea by modifying the specific gravity of the ocean waters. Taking his own numbers, and assuming the evaporation of the torrid zone to be sixteen feet per annum, deducting six feet for the downfall of the same region, and supposing the remaining ten feet to be precipitated in the extra tropical regions, the daily depression of the tropical ocean will amount to one thirty-sixth of a foot, or one-third of an inch.

The simultaneous downfall over a surface, say, twice as great in the higher latitudes, will increase the difference of level about one-sixth of an inch, making a total difference of half an inch. This will amount to but one-forty-eighth of an inch per hour. The movement required to restore an equilibrium so slightly disturbed would be scarcely sensible. Nor will the presence of salt in the ocean affect the case. It is a question of raising a certain amount of weight from one portion of a fluid surface and depositing it upon another. That the water left behind is salter than before neither increases nor diminishes the amount of movement consequent upon the disturbance of equilibrium.

Still less plausible is the assumption that the currents of the ocean are sensibly affected by the secretions of marine animals withdrawing from the waters their salts, and thus rendering them specifically lighter. The writer seems not to have considered that, if any weight were due to this consideration, it would neutralize, so far as it goes, the former, since these secretions take place mainly in the same seas which he supposes to become more dense in consequence of evaporation.

The last example which the committee will adduce to illustrate the character of the speculations which fill the volume under consideration is the theory propounded to account for the present condition of the inland seas of Asia, the Dead sea, the Caspian, and the Sea of Aral. These bodies of water have no present connexion with the ocean. The fact that they maintain a constant level demonstrates that the evaporation from their surface just balances the supplies which they receive from their tributaries.

If South America were to sink beneath the ocean, it is the opinion of the author of these speculations that the downfall of rain within their valleys would be so increased that their levels might be raised as high as that of the Mediterranean and Red sea, or higher, and that they would force to themselves outlets to the main ocean. It is his belief that such was once their condition, and that they have been reduced to their present state by the elevation of the South American continent in the midst of a great open ocean, from which they, in a former geological period, derived their principal supplies. We cannot deny that, if the theories in regard to evaporation, precipitation, and atmospheric circulation which we have been considering are true, this South American continent lies in the way of the winds which are presumed to be drawing supplies for watering northern Africa, Syria, and Persia; but as the portion of South America which these winds traverse is itself remarkably well watered, we do not understand how it should cut off supplies altogether, or even very seriously interfere with them. If the valley of the Mississippi furnishes an amount of evaporation equal to six-sevenths of its downfall, (we give this proposition not as the true one, but as that of Lieutenant Maury,) certainly that of the Amazon must be capable of doing no less. We cannot think, therefore, that the hypothesis of the work before the committee in regard to a former state of things in these depressed seas different from the present is well sustained by his own principles. Geologists will probably find more serious objections to urge against it.

The committee would hardly be justified in occupying more space with the theories of the work under consideration. It may be remarked, however, before leaving this part of the subject, that the writer sometimes displays a confusion of ideas in dealing with physical questions hardly creditable to one who undertakes to instruct the public upon such topics. Thus, in speaking of the great force necessary to put in motion the vast flood of waters which forms the Gulf Stream, he states that this force must be sufficient not only to move the mass with the observed velocity, but also to lift it at the same time up an inclined plane rising five or six feet to the mile. The propelling force he regards as something different from the difference of level caused by the expansion due to superior temperature. But the lifting force is certainly due to this expansion, and to nothing else. If a cubic mass of water a mile in linear dimensions, in the middle of a stationary ocean, were suddenly to be raised in temperature twenty degrees above the surrounding liquid, its surface would be elevated, and become, to use this writer's expression, "roof-shaped," overflowing the adjacent waters. Its downward pressure being diminished by this overflow, its entire mass would be lifted up; and this process would go on until the whole should have been brought to the surface of the sea. And this is what occurs in the Gulf Stream. If its propelling power is, as the writer supposes, independent of temperature, the force by which it is lifted acts perpendicularly to that without being a charge upon it.

Again, in reference to this same current, he propounds the following question, which, to say the least, conveys no very distinct notion of a physical agency: "May there not exist, between the waters of the stream and their fluid banks, always heaving and moving to the swell of the sea, a sort of *peristaltic* force, which, with other agents, assist (*sic.*) to keep up and preserve this wonderful system of ocean circulation?" Among the explanations of the charts there is given, on page 294 *et. seq.*, an elaborate calculation of the amount of solar heat absorbed in the evaporation of the water which annually falls within the Mississippi valley in the form of rain, and this is measured by estimating the weight of coal which would be required to produce by its combustion the same amount. The result of such a computation must, in any case, be surprising, but in this particular instance it is rendered more so by the assumption of the writer that a cubic foot of water requires three hundred and sixty pounds of coal to convert it into vapor—that is to say, about six times its own weight, or four and a half times its own bulk.

In concluding this portion of the subject, it may be observed that the large part of the discussions which we have been considering are avowedly transferred from a work, by the same author, entitled the "Physical Geography of the Sea," and published for his own benefit. Of the three hundred and eighty pages which make up the text of volume I of the "Sailing Directions," nearly two hundred are filled with this borrowed matter, and on scrutinizing the remainder we find large passages, often several pages consecutively, a second time introduced without citation, sometimes verbatim, and sometimes with slight verbal modifications. Were the question of continuing these publications to turn upon their presumed value in a scientific point of view, the committee could have no hesitation in saying that their discontinuance would be attended with no serious disadvantage. The facts of observation which they embody could be consolidated into a much more compact and manageable form, and their discussions of principles have, for the most part, been long before the public in an independent and well-known work.

In passing to consider the practical value of these publications, the committee may take occasion to observe, in the beginning, that there is a very considerable proportion of the mass which may at once be dismissed from consideration. It requires, for instance, but a very brief consideration to decide that nothing which is contained in the first of the large volumes before the com-

mittee, entitled "Sailing Directions, can be of any important use to the practical navigator. This remark extends no less to that portion of the contents of this volume which is professedly a "Description of the Charts" than to the rest, for this portion, so far from being confined to its professed subject, is, in the main, but a renewed presentation of the theories which have gone before, while the legends printed upon the face of the charts themselves contain all the explanations necessary to render them intelligible, and all that it is probable the navigator, except in rare instances, ever consults. This entire volume may, therefore, be safely pronounced to be practically useless. It contains nothing to justify the title under which it is published.

It is the second volume which embraces the "Sailing Directions" proper, if, indeed, it *be* proper to apply the term *directions* to an appalling mass of tabulated statistics of actual sailing and of abstract logs of vessels spread out over a surface of nearly nine hundred quarto pages. Scattered through such a maze the "directions" themselves are lost to view; and if the navigator who resorts to the work for information succeeds in finding the object of his search, he does so, probably, in most cases, at the expense of much waste of time and much trial of patience. The publication of the abstract logs appears to be a most wanton waste of valuable paper. That of the tabulated tracks of vessels is little better. If these things are given as authorities for the conclusions of the compiler, they are out of place. The practical navigator has no use for them, and no concern in knowing them. What is important to him is to know the conclusions themselves, and it is not presumable that his professional pursuits will leave him time to undertake the verification of their correctness by repeating the laborious processes by which they were deduced. Moreover, if this is the motive for their introduction here, voluminous as they are, they do not constitute the hundredth part of the nine or ten thousand logs which have been professedly consulted in preparing the material on which the "computed routes" and the corresponding "Sailing Directions" are founded, and hence the weight of their authority is comparatively insignificant. If they are introduced as examples merely to be compared with the computed routes or with each other as illustrative of the superiority of particular lines of sailing, it is probable that the labor of studying them out will deter ninety-nine out of a hundred persons from making the attempt.

It is claimed for the routes which have been computed and recommended by the compiler of these works that they have served very greatly to shorten passages between distant ports on almost every sea. Whether these claims are well or ill founded is not a question for this committee to settle. So much labor as has been expended upon the volumes and the charts before us ought not to have been wholly thrown away. It is to be hoped it has not been so. But the most brilliant success in this direction can be no justification of the publication of a heterogeneous and ill-digested mass of material, such as fills the volumes of "Sailing Directions," though it might justify, and even require, that the valuable results presumed to have been attained should be placed within the reach of every navigator. Were the tables of computed routes only published, or published with only the accompaniment of such brief textual explanations and directions as would be necessary to convey distinctly all that the compiler supposes that he has done in the way of shortening voyages in every sea to which his attention has been directed, a very small volume would suffice to conta in the whole, and the government would be greatly the gainer by substituting it for the unwieldy, cumbrous, and, for the most part, useless work, submitted to the committee. Without undertaking, therefore, to pronounce upon the positive value of that small portion of vol. II of the "Sailing Directions," which may be properly said to consist of matters according with the title, the committee cannot hesitate to recommend the discontinuance of the further publication of this volume "in its present form."

The three small tracts entitled "Nautical Monographs," which accompany the volumes, form two small a proportion of the mass of matter laid before the committee to require particular notice.

The charts will now be considered in the order of their classification. Series A is entitled "Track Charts." These charts exhibit the actual paths of a multitude of vessels as laid down from their logs. In the plan of the publication, this series is designed to consist of forty-six distinct sheets. Of these thirty-four have been laid before the committee, the remainder being yet unpublished.

The entire description of this series is embraced (Sailing Directions, vol. I, p. 281) in the following paragraph: "The different sheets of this series show at a glance the frequented and unfrequented parts of the ocean; they inform the navigator as to the general character of the wind and weather, the force and direction of the currents encountered by those who have preceded him in the same part of the ocean, and at the same season of the year." By means of the art of polychrome printing, and by the aid of various expedients of symbolization, all the particulars here enumerated are made to appear. But as these matters have for the most part been abundantly provided for in other charts, the value of the present series, if they have any, is to be found mainly in the exhibition of the tracks themselves.

But any one who shall attempt to follow even a single track amid the bewildering maze which cover the more frequented seas, will soon grow weary of the labor, and any navigator who shall attempt to shape for himself the most eligible route in view of all the experiences of his predecessors as he finds them here depicted, will be presently overwhelmed by the multitude of his data, and in most cases probably driven to abandon the effort in despair. Whatever, then, may be said of the others, there can be no doubt that the track charts ought to be wholly discontinued.

The sheets of series B are entitled "Trade Wind Charts." Of these only two appear to have been published—one for the Indian ocean, and the other for the Atlantic. The plans adopted for these are dissimilar. On the Indian ocean chart the directions of the winds in the trade-wind zone are generalized for the opposite months of February and August, and represented by means of arrows arranged in curves, which, with a remarkable uniformity of figure, especially for August, cover a great part of the surface. It is assigned as a reason for confining the representation to two months only of the year, that the many and great changes which these winds undergo render it difficult to exhibit them; and among other causes contributing to the difficulty, the *regularity* of these changes is mentioned as one—a circumstance which, if it be true, the committee have found not altogether intelligible.

Assuming, however, that the representation is correct for the seasons named, the simplicity of the indications would seem to make it quite possible, by means of a very few words of description, to convey all the information which is embodied in this chart in a form much more compact and quite as useful. The plan of the Atlantic chart is more simple, and is restricted to the single object of showing where the limits of the trade-wind belts, and of the equatorial and tropical calms, have been actually found by voyagers in the different months of the year. To this end parallels of latitude are drawn corresponding to every degree, intersected at intervals of five degrees of longitude by heavily drawn meridians. The spaces between these meridians are divided by lighter lines into twelve equal parts, of which one is appropriated to the observations which have been made anywhere between the heavy meridians in each month. The whole map is thus divided into small squares, within which the numbers of actual observations are written, so as to form a series of tables to be entered by arguments of months and latitude. The exhibit is not remarkably favorable to the doctrine of definitely fixed limits to the region of the trades or of the calms in any month; different navigators having varied in their experiences

of encountering them through a range of ten or twelve, and in a few extreme cases through as many as seventeen degrees of latitude. If the straggling cases were rare, while the great bulk of the observations fell upon a zone of but a degree or two in breadth, they might be regarded but as an important exception; but the fact is quite the reverse, hardly a single square within the large area covered with figures showing a numeral larger than four or five, except in the region of the equatorial variables; while there are many blank squares which have entries both north and south of them. We here discover why it is that the results of these observations have not been generalized. And we perceive also that all that can be positively affirmed in regard to these zones might be briefly expressed in a few lines, stating the rather wide limits of latitude between which navigators have encountered or lost these winds at different seasons, and within which other navigators may reasonably expect to meet with the same experience. It does not appear, therefore, to the committee that the interest of navigation would materially suffer were these charts to cease to be distributed.

Of series C, entitled "Pilot Charts," twenty sheets have been laid before the committee. This series embraces the results of the laborious analysis of wind operations recorded in the logs, to which allusion has already been made in this report. If any one of the classes is adapted to be of real and substantial value to the practical navigator, it is this. The plan of construction has been to map out the surface of the ocean into rectangles bounded by meridians and parallels of latitude, five degrees, in most instances, apart, and within each one of these rectangles to inscribe a *rose-de-vents* having sixteen radii, between which are written down, after a determinate order, the numbers of times the wind has been observed to blow in each month of the year from each of the sixteen principal points of the compass.

The numbers of observations of calm for each month have also a place assigned to them; and, in addition to these entries, the total number of winds from every quarter for each month is likewise recorded. The data thus furnished will enable the navigator to calculate, if he pleases, the ratio between the number of observed winds from any given quarter, for any season, to the total number of observations which have been made in that season; and thus, according to the assumption on which the presumed usefulness of the charts depends, the probability of encountering any given wind, at any given time, within any one of the rectangular areas into which the ocean is parcelled out upon the chart. It would evidently have much simplified the form and greatly increased the facility of using these helps to navigation had the compiler relieved the navigator of the labor of calculating these ratios, and substituted the ratios themselves in place of the absolute numbers entered in the charts, the totals being preserved as an evidence of the extent of the induction upon which the determinations are founded. And there is some reason to suppose that the same results, arranged in *tables*, to be entered by arguments of latitude and longitude, would have served the desired purpose more conveniently than the charts in which they are here presented. This method would, at least, have possessed the advantage of restricting the publication to those portions of the ocean's surface in regard to which the collected observations are sufficiently numerous to be really valuable; whereas, according to the plan adopted, large spaces are of necessity left blank for want of material to fill them, and other spaces are so meagerly provided as to be but little better than blanks. It is upon the basis of the "Pilot Charts" that the routes recommended in the "Sailing Directions" as the most favorable across particular seas, or between determinate ports, have been computed. The method of making these computations is explained at some length in vol. I of the "Sailing Directions," p. 300, *et seq.* The problem proposed is to find the route which shall be shortest in time between any two assigned points, having regard to the winds which will

probably be encountered by the navigator in passing through the successive squares across which his track may lie, and their effect in forcing him to deviate from the most direct course. The process is exceedingly laborious, and is for the most part tentative. Each successive square presents an independent problem, and for any proposed deviation of the tract through the preceding square this problem has to be attacked *de novo*. But it is an obvious possibility that what may seem to be a favorable route through one square may lead the navigator to a position in the next disadvantageous to his progress in the desired direction, so that the investigator may be repeatedly compelled to return upon his steps, and to recommence his labor at the starting point. In this process there are involved so many uncertainties that one might reasonably be permitted to regard the final result with a distrust which nothing but the test of actual trial would be likely to remove. It is claimed by the author that this test in most, perhaps in all, cases has been actually applied, and that his conclusions have always been satisfactorily sustained. The committee have no disposition to controvert these claims. It is true that the improved models of sailing vessels introduced in recent times have greatly shortened the duration of all long voyages; but it is very possible that a happier choice of route may have contributed to the same end. We find in vol. II of the "Sailing Directions," p. 236, a letter to the compiler from a discontented shipmaster, who loudly complains that he has followed the instructions of the "great book" to his sad discomfiture. He may be one of that unfortunate few whose untoward fate is essential to the truth of the "doctrine of chances." The question is not to be settled by the scattered experiences of here and there an individual, whether these experiences be favorable or otherwise.

It is worth remarking, however, that all the "computed routes" are given in the volume in the form of tables; and this circumstance confirms the impression of the committee, already expressed, that the data from which they are derived might equally well have been presented in the same form. Indeed, if anything could be advantageously presented in the form of charts, it would seem that these very routes, in which are condensed all the practical results designed to be wrought out by means of this formidable array of apparatus, should have preference before anything else. Charts, on which these routes should be distinctly laid down would, if the routes have really the great merit claimed for them, form a set of "Track Charts" worth possessing, and would far exceed in practical value all those that have been laid before the committee. "In their present form," therefore, it does not appear to be desirable that the "Pilot Charts" should continue to be further distributed.

The "Thermal Charts," forming series D, are next in order. These are twelve in number. They exhibit the surface temperature of the ocean for different seas and for the different months of the year, set directly down in figures at the several points where it has been observed. The seasons are indicated by the positions of the numerals, as direct or inverted, or semi-inverted, and the months by differences of color. As no particular benefit to navigation can be supposed to accrue from the use of charts of this description, the committee do not esteem it important to notice this series further. They take occasion to remark in passing, however, that the plan of construction is attended with this serious disadvantage, that where the material is abundant, the numerals are so crowded as to be nearly illegible, and where it fails, large surfaces are left entirely blank. This latter condition, indeed, occurs in many of the charts of every series.

The sheets of series E, three only in number, are entitled "Storm and Rain Charts." In these, as in "The Pilot Charts," the ocean's surface is mapped out into squares of five degrees of latitude by as many of longitude, and each of these squares is subdivided by vertical faint lines into twelve equal parts corresponding to the months of the year, these being crossed by other faint

lines dividing the same square into thirteen equal parts horizontally. Of the horizontal spaces, eight are devoted to the record of gales from the eight principal points of the compass; four to calms, rain, fog, and thunder and lightning, respectively, and the remaining one to the numbers of days of observation in each month within the particular area of five degrees square. The object of these charts, in the words of the compiler, is "to show the exceptions to what may generally be considered the prevailing condition of the weather at sea, and to determine from what quarter storms are most liable to occur for each month in every district."

Information of this character will probably be useful to the mariner, but it appears to the committee that it is precisely that kind of information which can best be given in words, or reduced to tabular form, if necessary, within the pages of a book. The data *are*, in fact, tabulated in the chart itself, each square or district forming a little independent table, to be entered by arguments of months and weather. The chart serves only the purpose of presenting these tables in an inconvenient form. The objection made to the "Pilot Charts"—that they present the actual numbers of the original observations, and not the relative numbers which measure the probability of a given occurrence, holds also here. The work which belongs to the compiler is thrown upon the navigator, and the same work (if the charts are really and generally used) is repeated a thousand times, when it might and should have been done once for all. The compiler seems ever to have himself been conscious of this great defect, for among the plates of vol. I of the "Sailing Directions" he has given an example of the possibility of reducing these data to a more useful form; and in what he calls the "Spotted Plates," twenty-four in number, of the same volume, (all taken together being not much larger than one of these charts,) he has presented a series of storm pictures of the entire Atlantic ocean for each month of the year, greatly better adapted to the practical use of the mariner than these ill-conceived sheets can possibly be.

The last series on the list of charts laid before the committee, marked F, is entitled "Whale Charts," and embraces five sheets. The object of these is indicated in the name. It is stated by the compiler to be "to show at a glance where this fish *(sic)* has been most hunted; when, in what years, and in what months it has been most frequently found; whether in shoals or as stragglers, and whether sperm or right." With this statement of the object, it appears to the committee that they may very fitly dismiss the subject, since, whatever may be the value of the charts to whalers, there can be no possible propriety in their general distribution.

In concluding this review the committee have to remark that one grave fundamental error characterizes the plan of construction of this entire work. It is this: that instead of the intelligible and practical conclusions which ought to have been the fruit of so much labor and research as have been manifestly expended, the investigator has deliberately turned over to the public the formidable array of data themselves, which his labors have gathered, and which it was his proper business to elaborate and interpret. The extended and laborious series of "Track Charts" show a portion of these data, but a portion so elementary in their character, and so confused in their mode of presentation, that, embodied as they are in these sheets, it is difficult to see of what use they can be even to the most patient inquirer. In the wind-roses of the "Pilot Charts" we have an example of the grouping of the data appropriate to the immediate subject of investigation, in form convenient for office duty; but the deductions from this study should have been expressed for the mariner, if at all, in definitely drawn lines, showing the routes which the investigation has proved (if it has, indeed, done anything of the kind) to be the most likely to be favorable, at given seasons, across given seas, and between given havens. If such an investigation is a difficult one, requiring much time, much patience, many trials, and many

figures, to lead to a satisfactory conclusion,—and is what it is, according to the testimony of the compiler of the charts himself—how can it be expected that the shipmaster, with all the cares of his vessel upon his mind and his hands, can find freedom to undertake it, after his voyage has commenced? And how many shipmasters are there whose competency to treat such a problem, under any circumstances, would probably be admitted, even by the very individual who has expended so much of his own personal labor to place in their hands the data for its solution in the form of these "Pilot Charts?"

The original idea of these publications was a good one; it is the manner of its execution that is faulty. It was fitting that the laborious analysis of ships' records which has been carried on at the Naval Observatory should be made. It is greatly desirable that it should be continued, and extended to every point of interest in meteorological science and research. It is desirable that the collected and classified results should be compared and studied, and that abstracts of them should be exchanged with institutions and individuals engaged in similar investigations elsewhere, in our own or in other lands. But it is by no means desirable that the immense mass of facts thus collected should be embodied in an indigested or half digested state, into publications designed to be scattered broadcast over land and sea. Out of their careful study may be deducted principles which may form the basis of instructions to navigators worthy to be called "Sailing Directions," and such instructions in any suitable form may very fitly be published by the government and circulated among seamen.

The committee, therefore, with entire unanimity, recommend the adoption of the following resolutions:

"*Resolved by the National Academy of Sciences,* That, in the opinion of this academy, the volumes entitled "Sailing Directions," heretofore issued to navigators from the Naval Observatory, and the "Wind and Current Charts," which they are designed to illustrate and explain, embrace much which is unsound in philosophy, and little that is practically useful; and that therefore these publications ought no longer to be issued in their present form.

"*Resolved,* That the records of meteorological phenomena and of other important facts connected with terrestrial physics, which, under the direction of the Navy Department, have been accumulated at the Observatory, are capable of being turned to valuable account, and that it is eminently desirable that such information should continue to be collected and subjected to careful discussion.

"*Resolved,* That the president of the academy be authorized and requested to communicate to the Secretary of the Navy a copy of the foregoing resolutions, and of this report, as a response to the inquiry addressed to the academy upon this subject by that officer."

All of which is respectfully submitted.

F. A. P. BARNARD, *Chairman.*
W. CHAUVENET.
ALEXIS CASWELL.
JOSEPH WINLOCK.
BENJAMIN PEIRCE.
J. E. HILGARD.
J. F. FRAZER.
J. D. DANA.
J. H. ALEXANDER.

L.

Constitution and by-laws of the National Academy of Sciences.

PREAMBLE.

Empowered by the act of incorporation, adopted by Congress, and approved by the President of the United States on the 4th day of March, A. D. 1863, the National Academy of Sciences do enact the following constitution and by-laws:

ARTICLE I.

Of members.

SECTION 1. The members of the Academy shall be designated as members, honorary members, and foreign associates.

SEC. 2. The Academy shall consist of the fifty members named in the act of incorporation, and of such others, citizens of the United States, as shall from time to time be elected to fill vacancies, in the manner hereinafter provided.

SEC. 3. Every member shall, upon his admission, take the oath of allegiance prescribed by the Senate of the United States for its own members, and, in addition thereto, an oath faithfully to discharge the duties of a member of the National Academy of Sciences to the best of his ability. He shall also subscribe the laws of the Academy.

SEC. 4. The members of the Academy shall be arranged in two classes, according to their special studies, viz: A, the class of mathematics and physics, and B, the class of natural history. The corporate members may select the class in which they desire to be arranged.

SEC. 5. The members of the classes shall arrange themselves in sections by inscribing their names under one of the following heads: Class A, *mathematics and physics;* sections—1, mathematics; 2, physics; 3, astronomy, geography, and geodesy; 4, mechanics; 5, chemistry.

Class B, *natural history;* sections—1, mineralogy and geology; 2, zoology; 3, botany; 4, anatomy and physiology; 5, ethnology.

But the Academy retains the power of transferring a member from one section to another.

SEC. 6. A member may be elected an honorary member of any section by a vote of a majority of such section.

SEC. 7. The Academy may elect fifty foreign associates, who shall have the privilege of attending the meetings of the Academy and of reading and communicating papers to it, but shall take no part in its business, and shall not be subject to its assessments.

They shall be entitled to a copy of the publications of the Academy.

ARTICLE II.

Of the officers.

SEC. 1. The officers of the Academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer; all of whom shall be elected for a term of six years by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner at the next stated session after the vacancy occurs.

SEC. 2. The officers of the classes shall be a chairman and a secretary, who

shall be elected at each January session. The nominations shall be open, and a majority of votes shall be necessary to elect.

Sec. 3. The officers of the Academy and the chairmen of the classes, together with four members, two from each class, to be annually elected by the Academy, at the January session, by a plurality of the votes, shall constitute a council for the transaction of such business as may be assigned to them by the constitution or the Academy.

Sec. 4. The president of the Academy, or in case of his absence or inability to act, the vice-president, shall preside at the meetings of the Academy and of the council; shall name all committees, except such as are otherwise especially provided for; refer investigations required by the government of the United States to members specially conversant with the subject, and report thereon to the Academy at its next January session, and, with the council, shall direct the general business of the Academy.

It shall be competent for the president in special cases to call in the aid upon committees of experts or men of remarkable attainments, not members of the Academy.

Sec. 5. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising with the president and council in cases of doubt, and reporting their action to the Academy at its January session. It shall be the duty of the home secretary to give notice to the members of the place and time of all meetings, and to make known to the council all vacancies in the list of members.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

Sec. 6. The treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, and keep a set of books showing a full account of receipts and disbursements. He shall present at each stated session a list of the members entitled to vote, and a general report at the January session. He shall be the custodian of the corporate seal of the Academy.

Article III.

Of the meetings.

Sec. 1. The Academy shall hold two stated sessions in each year: one in the city of Washington, on the third day of January, (unless that day falls on Sunday, when the session shall be held on the succeeding Monday;) and one in August, at such time and place as the Academy shall have determined upon, in private meeting, on the last day of the preceding January session.

Sec. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

Sec. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

Sec. 4. The Academy may divide into classes for scientific or other business. In like manner, the classes may divide into sections.

Sec. 5. The classes shall meet during such periods of the stated meetings of the Academy as may be fixed by the Academy. Special meetings of a class may be called by the council at the request of five members of the class.

Sec. 6. The stated meetings of the council shall be held at the times of the stated or special meetings of the Academy. Special meetings shall be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 7. No member who has not paid his dues shall take part in the business of the Academy.

ARTICLE IV.

Of elections, regulations, and expulsions.

SEC. 1. All elections shall be by ballot, unless otherwise ordered by this constitution; and each election shall be held separately.

SEC. 2. Whenever any election is to be held, the presiding officer shall name a committee to conduct it, to collect the votes, count them, and report the result to the Academy. The same law shall apply in the classes.

SEC. 3. Nominations for officers shall be made at the close of the first daily meeting of a stated session; and no candidate shall be voted for unless thus nominated.

SEC. 4. For election of members the council shall first decide the class in which the vacancy shall be filled. Each section of that class may then select one or more candidates after a discussion of their qualifications, and present their claims to the class, who shall select three to be presented in the order of their preference to the Academy; from these three the Academy shall elect by a majority of the members present. The member elect shall be assigned to the section in which he has been proposed. The Academy may nominate candidates in any section which fails to propose them for itself.

SEC. 5 Every member elect shall accept his membership personally or in writing before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 6. Elections of foreign associates shall be conducted as follows:

Each section shall report to its class, nominating a candidate whose special researches need not belong within the province of the section, but must be comprised within the range of the class.

From these candidates each class shall select one name to be presented to the Academy, and from these two names the Academy, after full discussion, shall make the election, at such time as it may have previously appointed for the purpose.

SEC. 7. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership.

SEC. 8. Resignations shall be addressed to the president and acted on by the Academy. No resignation of membership shall be accepted unless all dues have been paid.

SEC. 9. Members resigning in good standing will retain an honorary membership; being admitted to the meetings of the Academy, but without taking part in the business. Honorary members will not be liable to assessment.

SEC. 10. If any member be absent from four consecutive stated meetings of the Academy without communicating to the Academy a valid reason for his absence, his name shall be stricken from the roll of members.

SEC. 11. Members and officers habitually neglecting their duties shall be impeached by the council, and at once notified thereof in writing by the home secretary.

SEC. 12. Impeachments of members or officers shall first be tried before the council, which may be convened specially for such purpose. If it decides that the impeachment is proper, such impeachment shall be tried in private session before the Academy at its next stated meeting.

SEC. 13. The expulsion of a member shall be formally and publicly announced by the president at the stated session during which expulsion shall take place.

ARTICLE V.

Of scientific communications, publications, and reports.

SEC. 1. Papers on scientific subjects may be read at the meetings of the Academy, or of the classes or sections to which the subject belongs.

SEC. 2. Any member of the Academy may read a paper from a person who is not a member, and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

SEC. 3. The Academy shall provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports shall originate with the classes to which the subjects belong, and be by them submitted to the Academy for approval, except requests from the government of the United States, which shall be acted on by the president, who will in such cases report, if necessary, at once to the government, and to the Academy at its next stated meeting.

SEC. 5. The judgment of the Academy shall be at all times at the disposition of the government upon any matter of science or art within the limits of the subjects embraced by it.

SEC. 6. An annual report, to be presented to Congress, shall be prepared by the president, and before its presentation submitted by him first to the council, and afterwards to the Academy at its January meeting.

SEC. 7. Medals and prizes may be established, and the means of bestowing them accepted by the Academy upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

ARTICLE VI.

Of the property of the Academy.

SEC. 1. All investments shall be made by the treasurer in the corporate name of the Academy in stocks of the United States,

SEC. 2. No contract shall be binding upon the Academy which has not been first approved by the council.

SEC. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the council.

ARTICLE VII.

Of additions and amendments.

Additions and amendments to the constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change may be given at any stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the Academy at its next stated session, with a recommendation that it be accepted or rejected. Its report shall be considered by the Academy in committee of the whole, and immediately thereafter acted on. If the addition or amendment receive two-thirds of the votes present, it shall be declared adopted, and shall have the same force as the original law.

BY-LAWS.

Of the officers.

I. In the absence of the chairman or secretary of a class, a member shall be chosen to perform his duties temporarily, by a plurality of the *viva voce* votes, upon open nomination.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the Academy at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

Of the meetings.

III. A committee of arrangements, for each stated session of the Academy, of five members, shall be appointed by the president, the class secretaries to be *ex officio* two of the members of the committee. This committee shall meet not less than two weeks previous to each meeting. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, &c.; and to arrange the order of reading, and in general to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows:

1. Chair taken by the president, or, in his absence, the vice-president.
2. Roll of members called by home secretary.
3. Report by treasurer of members entitled to vote.
4. Minutes of the preceding meeting read and approved.
5. Stated business.
6. Reports of president, secretaries, treasurer, classes, and committees.
7. Business from council.
8. Other business.
9. Communications from members.
10. Communications from persons not members.
11. Announcements of the death of members. Biographical notices read.
12. Rough minutes read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless otherwise directed.

VI. It shall be in order for twelve members to require that any matter of business be discussed in committee of the whole for amendment; the vote upon amendments to be taken in the whole Academy; and the amended proposition or propositions to be similarly voted on.

VII. The scientific meetings shall be convened at twelve o'clock m., in order to allow time for the business meetings of the Academy, and for the meetings of classes, sections, and committees.

Of elections and obituaries.

VIII. No more than ten foreign associates shall be elected at any one stated session.

IX. The death of members shall be announced by the president on the last day of each stated session, when a member shall be selected by the Academy to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member shall be selected by the Academy in place of the first, and so on until the duty is performed.

X. The deaths of such eminent scientific men of the country as have taken place since the last session of the Academy shall be announced by the president. The names shall be selected by the council.

Of scientific communications, publications, and reports.

XI. An analysis of the memoirs and reports read in the meeting of the classes shall be given by the secretaries of the classes to the home secretary for publication in the proceedings of the Academy. For any failure in this duty, the delinquent officer shall be impeached by the home secretary.

XII. The secretaries shall receive memoirs at any time, and report the date

of their reception at the next session. But no memoir shall be published unless it has been read before the Academy, class, or section, and ordered to be published by the Academy. Papers shall be published in the order in which they were registered, but papers which have not been sent to the secretary within a month from the time of their reading shall not be published without a special vote of the Academy.

XIII. Memoirs shall date in the records of the Academy from the day of their presentation to the Academy, and this order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XIV. The publication of any communication to which remonstrance is made by the section to which the subject belongs shall be suspended until a second time authorized by a vote of the Academy.

XV. Papers from persons not members, read before the Academy, classes, or sections, and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committees shall report to the Academy as early as practicable, and not later than the next stated session. If they do not then report they shall be discharged, and the paper referred to another committee.

XVI. Abstracts of papers published in the transactions of other societies or in journals may be communicated orally to the Academy; and if, on submitting any such communication to a committee, its publication be approved, it may be ordered for publication on a vote of the Academy.

XVII. Short communications or abstracts of memoirs may be sent by any member to the home secretary, who shall, if requested by the author, without delay circulate them among the members.

XVIII. An annual of the Academy shall be prepared by the secretaries, and published on the first day of each year.

XIX. The printing of the Academy shall be under the charge of the secretaries and the treasurer, as a committee of publication, who shall report in relation thereto at each January meeting of the Academy.

XX. The annual report of the Academy may be accompanied by a memorial to Congress, in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XXI. The home secretary shall present to the council estimates for books and stationery, binding, &c., required for the use of the Academy.

Of the property of the Academy.

XXII. The proper secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XXIII. The books, apparatus, archives, and other property of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XXIV. A stamp corresponding to the corporate seal of the Academy shall be kept by the secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels or other proper marks of similar device shall be placed upon objects not admitting of the stamp.

Of changes in the by-laws.

XXV. Any by-law of the Academy may be amended or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy; provided the same shall be approved by a majority of the members present at the next stated session.

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